SCIENCE

VOL. LXVII FEBRUARY 24, 1928 No. 1730

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SCIENCE: A Weekly Journal devoted to the Advancement of Science, edited by J. McKeen Cattell and published every Friday by

THE SCIENCE PRESS

New York City: Grand Central Terminal.

Lancaster, Pa. Garrison, N. Y.

Annual Subscription, $6.00. Single Copies, 15 Cts.

SCIENCE is the official organ of the American Association for the Advancement of Science. Information regarding membership in the Association may be secured from the office of the permanent secretary, in the Smithsonian Institution Building, Washington, D. C.

Entered as second-class matter July 18, 1923, at the Post Office at Lancaster, Pa., under the Act of March 3, 1879.

ATOMIC HYDROGEN AS AN AID TO INDUSTRIAL RESEARCH[1]

IT is difficult for me to express adequately my appreciation of the honor you have conferred upon me through the award of this beautiful medal. I wish to thank you and also my other friends, Hendrick and Whitney, for the kind, although exaggerated words spoken about me.

I am sure that those of you who know Whitney well, or in fact all you who have just heard him speak, will understand that this medal should properly be regarded as a second award to him. The work for which this medal is now given was made possible by the remarkable inspiration and guidance which only Whitney can give.

Although I am a chemist by training, my work during recent years has been mostly in physics. The chemical work I have done has been largely purely scientific, started, at least, without thoughts of practical applications. Thus when I received notice of the action of the Perkin Medal Committee, while I was in Italy a few months ago, it puzzled me that I should have been chosen, especially when I considered that the medal is given for work in applied chemistry. I can assure you that I am not guilty of any deep laid plan to secure this medal. It came to me as a complete surprise—a surprise similar to those I have experienced when I have first realized that some purely scientific observations that I had made were capable of industrial applications.

On returning home from abroad, and finding that the committee had made the award mainly for my work on atomic hydrogen and its applications to welding, I was at first inclined to choose as a subject for this address an account of other work on atomic hydrogen completed more than ten years ago, but which I have neglected to publish except in such abbreviated form that it is nearly useless. Since one of the objects of the Perkin Medal is to stimulate research, it would seem particularly fitting that this award should thus lead directly to the publication of the results of investigations which would otherwise largely be lost.

[1] Address given on the occasion of the presentation of the Perkin medal, on January 13, at a joint meeting of the Society of Chemical Industry, Société de Chimie Industrielle, American Chemical Society and American Electrochemical Society.

The work that I refer to was experimental work extending over more than a year, on the kinetics of the interaction between hydrogen and oxygen at low pressures in contact with a hot tungsten filament. At temperatures below 1600°K the oxygen oxidizes the tungsten exactly as though no hydrogen were present, but an adsorbed monatomic film of oxygen poisons the filament so that the hydrogen can not be dissociated into atoms as it would be if there were no such film. The hydrogen is incapable of interacting directly with this adsorbed oxygen. However, after the oxygen has been used up by this reaction and gradual evaporation of the film has exposed a few tungsten atoms on the surface of the filament, the hydrogen suddenly and almost instantly removes the rest of the oxygen in the film and thus permits the dissociation of the remaining hydrogen. Without the hydrogen, the oxygen film would not evaporate appreciably. These experiments prove that the interaction between oxygen and hydrogen on tungsten takes place only between adjacent adsorbed atoms—a kind of flank attack. A direct action between the oxygen and hydrogen does not occur. These phenomena are clearly identical in character with the electro-chemical phenomena of passivity—a subject which has not been well understood.

This work, however, as you see, is pure physical chemistry, and so is not really a suitable subject for this address. I trust, however, that this award will stimulate research equally well by leading me to publish this material in its proper place at an early date.

Somewhat over a year ago I read a paper before the American Chemical Society on atomic hydrogen and its application to the welding of metals. Although the industrial applications of this process are developing rapidly, I have not been particularly closely associated with this recent progress, and therefore do not feel qualified to address you on this subject.

I believe the primary object of the Perkin Medal is to do honor to the memory of Sir William Perkin, that pioneer who devoted himself to pure scientific research after having led in the industrial applications of research for fifteen years. This object is best attained by encouraging the kind of research that he valued so highly. The medal should thus be regarded not as a reward for accomplishment nor as a prize to stimulate competition in research, but rather as a means of directing attention to the value of research and to the methods of research that are most productive. Having this in mind, I am going to tell you, although somewhat reluctantly, the history of some of my own work, in so far as it illustrates a method of industrial research that has proved valuable.

Two Types of Industrial Research

The leaders of industries are frequently conscious of the need of improvement in their processes and even of the need of new discoveries or inventions which will extend their activities.

It is thus logical and often extremely profitable to organize research laboratories to solve specific problems. Efficiency requires that the director shall assign to each worker a carefully planned program. Experiments which do not logically fit in with this program are to be discouraged.

This type of industrial research, which should often be called engineering rather than research, has frequently been very successful in solving specific problems, but usually along lines already foreseen.

This method, however, has serious limitations. Directors are rare who can foresee the solutions sufficiently well to plan out a good campaign of attack in advance. Then, too, the best type of research man does not like to be told too definitely what must be the objects of his experiments. To him scientific curiosity is usually a greater incentive than the hope of commercially useful results. Fortunately, however, with proper encouragement, this curiosity itself is a guide that may lead to fundamental discoveries, and thus may solve the specific problems in still better ways than could have been reached by a direct attack; or may lead to valuable by-products in the form of new lines of activity for the industrial organization.

Of course no industrial laboratory should neglect the possibilities of the first and older method of organized industrial research. I wish, however, to dwell this evening upon the merits of the second method in which pure science or scientific curiosity is the guide.

The History of the Gas-Filled Lamp

I first entered the research laboratory of the General Electric Company in the summer of 1909, expecting in the fall to return to Stevens Institute, where I had been teaching chemistry. Instead of assigning me to any definite work, Dr. Whitney suggested that I spend several days in the various rooms of the laboratory, becoming familiar with the work that was being done by the different men. He asked me to let him know what I found of most interest as a problem for the summer vacation.

A large part of the laboratory staff was busily engaged in the development of drawn tungsten wire made by the then new Coolidge process. A serious difficulty was being experienced in overcoming the "off-setting" of the filaments, a kind of brittleness which appeared only when the lamps were run on alternating current. Out of a large number of

samples of wire, three had accidentally been produced which gave lamps that ran as well with alternating as with direct current, but it was not known just what had made these wires so good. It seemed to me that there was one factor that had not been considered, that is, that the off-setting might possibly be due to impurities in the wire in the form of gases. I therefore suggested to Dr. Whitney that I should like to heat various samples of wire in high vacuum and measure the quantities of gas obtained in each case.

In looking through the laboratory I had been particularly impressed with the remarkably good methods that were used for exhausting lamps. These methods were, I thought, far better than those known to scientific research workers. My desire to become more familiar with these methods was undoubtedly one of the factors that led me to select for my first research an investigation of the gas content of wires.

After starting the measurements that I had planned, I found that the filaments gave off surprisingly large quantities of gas. Within a couple of weeks I realized that something was entirely wrong with my apparatus, because from a small filament in a couple of days I obtained a quantity of gas which had, at atmospheric pressure, a volume 7,000 times that of the filament from which it appeared to have come; and even then there was no indication that this gas evolution was going to stop. It is true that in the literature, for example in J. J. Thomson's book on the "Conduction of Electricity Through Gases," one found many statements that metals in vacuum give off gases almost indefinitely, and that it is impossible to free metals from gas by heating. Still I thought that 7,000 times its own volume of gas was an entirely unreasonable amount to obtain from a filament. I spent most of the summer in trying to find where this gas came from, and never did investigate the different samples of wire to see how much gas they contained. How much more logical it would have been if I had dropped the work as soon as I found that I should not be able to get useful information on the "off-setting" problem by the method that I had adopted.

What I really learned during that summer was that glass surfaces which had not been heated a long time in vacuum slowly give off water vapor, and this reacts with a tungsten filament to produce hydrogen, and also that vaseline on a ground glass joint in the vacuum system gives off hydrocarbon vapor, which produces hydrogen and carbon monoxide.

To me, however, that summer's work was so interesting that I dreaded to return to the comparative monotony of teaching, and gladly accepted Dr. Whitney's offer to continue at work in the laboratory. No definite program of work was laid down. I was given first one assistant and then others to continue experiments on the sources of gas within vacuum apparatus, and a study of the effects produced by the introduction of various gases into tungsten filament lamps. The truth is that I was merely curious about the mysterious phenomena that occur in these lamps. Dr. Whitney had previously found that gases have a habit of disappearing in lamps, and no one knew where they went to, so I wanted to introduce each different kind of gas that I could lay my hands on into a lamp with a tungsten filament and find out definitely what happened to that gas.

It was the universal opinion among the lamp engineers with whom I came in contact that if only a much better vacuum could be produced in a lamp, a better lamp would result. Dr. Whitney particularly believed that every effort should be made to improve the vacuum, for all laboratory experience seemed to indicate that this was the hopeful line of attack on the problem of a better lamp. I felt, however, that I really didn't know how to produce a better vacuum, and instead, proposed to study the bad effects of gases by putting gases in the lamp. I hoped that in this way I would become so familiar with these effects of gas that I could extrapolate to zero gas pressure, and thus predict, without really trying it, how good the lamp would be if we could produce a perfect vacuum.

I should like to add here parenthetically, that this principle of research is one which I have found extremely useful on many occasions. When it is suspected that some useful result is to be obtained by avoiding certain undesired factors, but it is found that these factors are very difficult to avoid, then it is a good plan to increase deliberately each of these factors in turn so as to exaggerate their bad effects, and thus become so familiar with them that one can determine whether it is really worth while avoiding them. For example, if you have in lamps a vacuum as good as you know how to produce, but suspect that the lamps would be better if you had a vacuum say 100 times as good, it may be the best policy, instead of attempting to devise methods of improving the vacuum, to spoil the vacuum deliberately in known ways, and you may then find either that no improvement in vacuum is needed, or may find just how much better the vacuum needs to be.

During these first few years, while I was thus having such a good time satisfying my curiosity, and publishing various scientific papers on chemical reactions at low pressures, I frequently wondered whether it was quite fair that I should spend my whole time in an industrial organization on such purely scientific work, for I confess I didn't see what applications could be made of it, nor did I even have any applications in mind. Several times I talked the matter over

with Dr. Whitney, saying that I could not tell where this work was going to lead us. He replied, however, that it was not necessary, as far as he was concerned, that it should lead anywhere. He would like to see me continue working along any fundamental lines that would give us more information in regard to the phenomena taking place in incandescent lamps, and that I should feel perfectly free to go ahead on any such lines that seemed of interest to me. For nearly three years I worked in this way with several assistants before any real application was made of any of the work that I had done.

In adopting this broad-minded attitude Dr. Whitney, I believe, showed himself to be a real pioneer in the new type of modern industrial research.

For my study of the effect of gases, I had to devise new types of vacuum apparatus. I needed particularly to be able to analyze the small quantities of gas that existed in the tungsten lamp. With some of this special apparatus I was able to make a practically complete quantitative analysis of an amount of gas which would occupy about 1 cubic millimeter at atmospheric pressure. In this sample of gas we could determine the percentages of oxygen, hydrogen, nitrogen, carbon dioxide, carbon monoxide and the inert gases.

In regard to the fate of the different gases which I introduced into the lamp bulb, I found that no two gases acted alike. Oxygen attacked the filament and formed tungstic oxide WO_3. That seemed simple enough, but I found that the kinetics of the reaction presented many features of considerable scientific interest.

In studying the effect of hydrogen, very peculiar phenomena were observed. A limited amount of hydrogen disappeared and became adsorbed on the bulb where it remained in a chemically active form, capable of reacting with oxygen at room temperature, even long after the tungsten filament had been allowed to cool. This suggested hydrogen atoms and seemed to confirm some conclusions that I had already drawn from observations on the heat losses from tungsten filaments in hydrogen at atmospheric pressure. In making squirted tungsten filaments and sometimes in cleaning the drawn wire, filaments were heated in this manner in hydrogen. Because of the fact that tungsten filaments melt at a temperature more than 1500° higher than platinum, it had seemed to me that tungsten furnishes a tool of particular value for the scientific study of phenomena in gases at high temperatures. From my work on lamps I knew approximately the relation between the resistance of tungsten wire and its temperature, and could thus use a tungsten wire as a kind of resistance thermometer. By connecting a voltmeter and an ammeter to the tungsten filament which was being heated in hydrogen, I could determine the temperature from the resistance and also find the heat loss from the filament in watts. I wanted to see if anything abnormal happened when the temperature was raised to the extremes which were only possible with tungsten.

The results greatly interested me, for they showed that the energy loss through the gas, which increased in proportion to the square of the temperature up to about 1800°K, increased at a much higher rate above that, until at the highest temperatures the energy varied in proportion to about the fifth power of the temperature. This result could be explained if the hydrogen at high temperatures were dissociated into atoms. The diffusion of the hydrogen atoms from the filament, and their recombination at a distance from it would cause an enormous increase in heat conduction. After publishing these preliminary results, I was naturally much interested in getting any other information I could in regard to the properties of these hydrogen atoms. A very large number of experiments, extending over several years, were thus made in this study of atomic hydrogen. Nearly all of these experiments would have seemed quite useless, or even foolish, to a man who was making a direct and logical attack on the problem of improving tungsten lamps.

When nitrogen at low pressure was introduced into a bulb containing a tungsten filament at extremely high temperatures, such as 2800°K, the nitrogen disappeared at a rate which was independent of its pressure—in other words, here was a case of a reaction of zeroth order. This suggested that the reaction velocity was limited by the rate at which the tungsten evaporated from the filament. To check this hypothesis the rate of loss of weight of filaments at various temperatures was measured in good vacuum. This rate varied with the temperature in accordance with known thermodynamic laws, and since the rate per unit area was independent of the size of the filament, it was concluded that the loss of weight was really due to evaporation and not to chemical action of residual gases or to electric currents that passed from the filament to the surrounding space.

A comparison of the rate of disappearance of nitrogen with the loss of weight in the filament showed that one molecule of nitrogen disappeared for every atom of tungsten that evaporated. A brown compound WN_2 was formed which deposited on the bulb and decomposed when water vapor was introduced, forming ammonia gas.

From time to time the question kept arising—how good would a lamp be if it had a perfect vacuum; and now, from studies of the character I have described,

began to have an answer. Hydrogen, oxygen, nitrogen, carbon monoxide, and in fact every gas that I introduced, with the exception of water vapor, did not produce blackening of the lamp bulb. The serious blackening that occurred with only small amounts of water vapor depended upon a cyclic reaction in which atomic hydrogen played an essential part. The water vapor molecules coming in contact with the hot filament produce a volatile oxide of tungsten, and the hydrogen is liberated in atomic form. The volatile oxide deposits on the bulb where it is reduced to the metallic state by the atomic hydrogen, while the water vapor produced returns to the filament, and causes the action to be repeated indefinitely. Thus a minute quantity of water vapor may cause a relatively enormous amount of tungsten to be carried to the bulb.

The question then arose whether the traces of water vapor, which might still exist in a well-exhausted lamp, were responsible for the blackening which limited the life or the efficiency of many of these lamps. We made some tests in which well-made lamps were kept completely immersed in liquid air during their life so that there could be no possibility of water vapor coming in contact with the filament. The rate of blackening, however, was exactly the same as if no liquid air had been used.

Having thus proved that the blackening of a well-made lamp was solely due to evaporation, I could conclude with certainty that the life of the lamp would not be appreciably improved even if we could produce a perfect vacuum.

Early in 1911 Mr. William Stanley, one of the pioneers in the electrical industry, felt that our company should do more fundamental work in connection with heating devices. Since I had become interested in the theory of heat losses from filaments in gases, I was glad to do work along these lines, so that I undertook to direct a small laboratory at Pittsfield, Mass., at which I spent about two days a week. Besides studying the heat losses from plane surfaces at various temperatures, I measured the heat losses from wires of various sizes in air at different temperatures, working at first with platinum wires, and was able to develop a theory of the heat losses which enabled me to calculate the loss from a wire of any size at any temperature in any gas, assuming however that the gas did not dissociate at high temperatures.

Having now a definite theoretical basis on which to calculate the normal loss by convection, I was able to prove that the abnormal rate of heat loss which I had previously observed with tungsten filaments at high temperatures in hydrogen was due to actual dissociation, and in fact I was thus able to calculate the heat of dissociation and the degree of dissociation at different temperatures.

However, to make sure of these conclusions, I wished to make measurements of the heat losses in gases which could not possibly dissociate, and therefore undertook experiments with heated tungsten wires in mercury vapor at atmospheric pressure. A little later I made experiments with nitrogen to see if this gas dissociated at high temperatures but found that it did not do so. In both of these gases the filaments could be maintained at temperatures close to the melting point for a far longer time than they could be if heated in vacuum at the same temperature. Thus the rate of evaporation was greatly decreased by the gas, many of the evaporating tungsten atoms being brought back to the filament after striking the gas molecules.

By this time I was familiar with all the harmful effects which gas can produce in contact with filaments and knew under what conditions these bad effects could be avoided. Particularly I realized the importance of avoiding even almost infinitesimal traces of water vapor. Thus, when I found a marked effect of mercury vapor and nitrogen in reducing the rate of evaporation, it occurred to me that it might be possible to operate a tungsten filament in gas at atmospheric pressure and obtain a long useful life. Of course, it would be necessary to raise the temperature far above that at which the filament could be operated in vacuum so as to compensate for the serious loss in efficiency due to convection, by the improved efficiency resulting from the rise in filament temperature. Whether or not the increased rate of evaporation, due to this increase in temperature, would more than offset the decrease in the rate due to the gas, was a matter that could only be tested by experiment.

In connection with the studies of the heat losses from filaments of various diameters at incandescent temperatures, I had found that the heat loss increased only very slowly with the diameter, so that the loss per unit area from a small filament was enormously greater than from a large filament. Calculations showed that it was hopeless to get practical lamps with filaments in nitrogen, if these filaments were of very small diameter. For example, a filament one mil in diameter, which corresponds to an ordinary 25 watt lamp, if run in nitrogen at atmospheric pressure would consume 4.8 watts per candle at a temperature of 2,400° K, which would give 1 watt per candle with a filament in vacuum. This great loss in efficiency is due to the cooling effect of gas. To bring back the efficiency of the gas-filled lamp to that of the vacuum lamp, it would be necessary to raise the temperature from 2,400 to 3,000° K, which would have caused a 2,000-fold increase in the rate of evaporation, and such an increase could certainly not be

compensated for by the effect of the gas in retarding the evaporation.

With filaments of much larger diameter, however, the effect of the gas in decreasing the efficiency was not nearly so marked. We therefore constructed lamps having filaments of large diameter in the form of a single loop and filled these lamps with nitrogen at atmospheric pressure. We ran these lamps with a filament temperature so high that in spite of the gas the efficiency corresponded to about 0.8 watt per candle, instead of the usual 1 watt per candle at which we tested our vacuum lamps. We were disappointed to find that these lamps blackened much more rapidly than vacuum lamps of similar efficiency, so that the total useful life of the lamp was short.

This result, which is what most lamp engineers would have expected, seemed to indicate that the necessary rise in temperature to offset the heat losses by the gas increased the evaporation by more than the amount of the reduction in evaporation due to the gas. If I had not previously become so familiar with the behavior of various gases, this discouraging result might easily have stopped further experimenting in this direction. However, I noticed that the bulb had *blackened* during the short life of the lamp whereas from my knowledge of the interaction of tungsten and nitrogen I had expected a deposit of a clear brown color. I felt that the black deposit, therefore, could mean only one thing—water vapor, notwithstanding the fact that to avoid this water vapor we had taken precautions which were greater, I believe, than had ever been used before for the preparation of moisture-free gases and glass surfaces. We were thus led to take still greater precautions and use still larger bulbs so that the glass surfaces could not become overheated by the convection currents in the gas that rose from the filament. We were then soon able to make lamps having a life of over 1,000 hours with an efficiency about 30–40 per cent. better than could have been obtained with filaments in vacuum.

As I look back upon these experiments I feel that we were very fortunate at that time in not having had at our disposal a supply of argon gas. From theoretical reasons I had concluded that argon should be better than nitrogen, and if I had had argon I should therefore probably have tried it first. If these lamps had blackened, because of traces of water vapor, I would naturally have attributed this to the increase in evaporation caused by the high temperature, and would have had no reason for suspecting that water vapor was the cause of the trouble, for, of course, in argon a brown deposit would not be expected in any case.

The lamps that we were able to make in this way, with an improved efficiency, were limited to those which took a current of 5 amperes or more, so that the method was not applicable for 110-volt lamps with less than 500 watts. Some time later, however, it occurred to me that the benefits derived from the large diameter of the filament could be obtained with one of smaller diameter by coiling the filament in the form of a helix, bringing the turns of the helix very close together. In this way, and by the use of improved tungsten filaments that do not sag so readily at high temperatures, and by using argon instead of nitrogen, it has gradually been possible to construct gas-filled lamps which are better than vacuum lamps down to wattages of about 40 or 50 watts. These smaller lamps, although not much better in efficiency than the vacuum lamp, have the advantage of giving a much whiter light. In the case of the larger lamps, the use of the gas filling together with the special construction of the lamp more than doubles the efficiency.

The invention of the gas-filled lamp is thus nearly a direct result of experiments made for the purpose of studying atomic hydrogen. I had no other object in view when I first heated tungsten filaments in gases at atmospheric pressure.

Even at the time that I made these experiments at higher pressures, they would have seemed to me useless if my ***prime object*** had been to improve the tungsten lamp.

I hope I have made clear to you the important rôle that properly encouraged scientific curiosity can have in industrial research. This illustration that I have given is not at all exceptional. I could have given any one of several others equally well.

Many industrial laboratories have followed Dr. Whitney's lead in devoting a fairly large fraction of their activities to these rather purely scientific researches. Certain men at least are not expected to be responsible for practical applications, but are freely allowed to make fundamental scientific investigations. The type of man who does this work best can usually be attracted only to those industrial laboratories that have adopted this policy.

However, I do not believe that this second method of research is growing in popularity solely because it is found to be profitable. I feel rather that most of our leaders in industrial research are eager to adopt this method, in so far as economic factors may permit, because they realize the debt that modern industry owes to the pure science of the past and because the modern conceptions of service and the growing ***esprit de corps*** of American industry help make them glad of any opportunity to contribute to scientific knowledge. I know personally that such motives as these have guided Dr. Whitney in the leadership he has taken.

I believe in the near future there will be a much increased demand for men with scientific training who are capable of doing more independent thinking.

Better Education Needed

Our schools and universities devote so much effort to imparting information to students that they almost neglect the far more important function of teaching the student how to get for himself what knowledge of any subject he may need. Even in grammar school, children are crammed with more information on arbitrarily selected subjects than even the average well educated adult can retain.

Of course students should be taught the fundamental principles of mathematics and of various sciences, as well as of other subjects, but much of the knowledge of data upon which these principles depend and other necessary information should be obtained by the efforts of the student through experimentation and individual reading.

As I look back on my own school and college days, it seems to me that the things of most value were learned spontaneously through interest aroused by a good teacher, while the required work was usually comparatively uninteresting. The university student should have leisure for some independent work and opportunities for continuing his interest in hobbies of various kinds which he should have had long before he entered college. I realize that it is difficult so to arouse the student's interest that he will spend the added leisure in these ways rather than in spending still more on the bleachers cheering the football team in their practice games. But a well planned effort is worthwhile.

The importance of arousing even a young boy's interest in independent work can hardly be overemphasized. My real interest in science was derived from my brother Arthur, who encouraged me to have a workshop at the age of 9, and later a laboratory when I was only 12.

I can illustrate my father's influence in stimulating independence by the following incident. When I was 12 I climbed one or two Swiss mountains of moderate height with my older brother Arthur. Soon after Arthur had to go to Heidelberg to arrange for his studies, thus leaving me with my mother and younger brother at a hotel in the Rhone Valley. I had become so enthusiastic over mountain climbing that I wished to climb everything in sight, but the dangers of Alpine climbing were such that my mother did not dare let me go alone. When my father arrived for a week-end visit from Paris, he consented to allow me to climb alone any mountain I liked if I would promise to do it in accord with the following three rules: (1) I must stay on a distinct trail; (2) I must use the same trail going and returning; (3) I must make certain of returning at 6 o'clock by allowing as much time for descending as for ascending. Before these rules went into effect, however, I had to prove that I could and would make such sketches, maps and notes of the trails used for the ascent that I could always return by the same route. I thus climbed several mountains about 7,000 feet high, often requiring several days of repeated effort before I could discover a route that led to the top. Perhaps it is this experience which makes me even to-day always wish to find my own way rather than be told the way.

Until I was fourteen I always hated school and did poorly at it. At a small boarding school in the suburbs of Paris, however, being an American and having a friend who was influential with the head of the school, I was freed from much of the absurdly rigorous discipline to which the French boys were subjected. Thus, I could spend time alone in the school laboratory and was encouraged by one of the teachers to learn to use logarithms and solve problems in trigonometry, subjects not required by the curriculum.

I have been fortunate in having many wonderful teachers. Three of them have been recipients of this Perkin Medal. Whittaker and Chandler were my teachers at Columbia and Whitney during the last eighteen years. Professor R. S. Woodward, at Columbia, in connection with his courses in mechanics, was extremely stimulating and encouraged me to choose and solve my own problems for class work instead of those required in the regular course.

I should like to see spontaneous work of this kind take a much more prominent part in our educational system—at least for students who have more than average ability.

The Value of Hobbies

Very great benefit may be derived from hobbies. Probably each person should have several of them. Just recently I met a small boy, only six years old, who had an overpowering, wide-eyed enthusiasm for collecting insects. He weighed each one of them within a milligram, and then, after desiccating them thoroughly over calcium chloride, weighed them again. Many elaborate notes and even correspondence resulted. I am afraid our universities, with their dormitories and other standardizations, tend to discourage such wholesome individual activities.

Of course, after talking of hobbies, I can not resist the temptation to tell you something of my own. Perhaps my most deeply rooted hobby is to under-

stand the mechanism of simple and familiar natural phenomena. I will give only two illustrations, but these, I hope, will make you see how easy it is to find around us simple phenomena that are not well understood.

Every chemist knows that after he stirs a liquid in a beaker having a precipitate in the bottom, the precipitate collects near the center. Probably few of you know why this is so. It is not due to the slower velocity of rotation near the center, nor to the slower motion with respect to the glass. This is proved by the fact that if you put the beaker, with the precipitate in suspension in the liquid, upon a rotating table, the precipitate will collect in a ring as far from the center as possible, although the relative angular motion of the beaker and its contents are the same as before. A little study proves that the phenomena are due to unbalanced centrifugal forces. For example, when the liquid is stirred, so as to set it in rotation, centrifugal force produces a greater hydrostatic pressure near the walls of the beaker. But the liquid very close to the bottom surface of the beaker, because of friction, can not rotate so fast, and therefore the centrifugal force is not so great and does not counteract the radial hydrostatic pressure difference existing in the upper layers. The liquid in contact with the glass bottom is thus forced inwards and carries the precipitate with it.

The phenomena connected with the formation and the disappearance of ice in a large lake, such as Lake George, have interested me for years. One clear night at the end of December, when the water of a large bay was at a uniform temperature of not over 0.2° C. and the air temperature was $-22°$ C., ice which formed slowly at some places on the shore, melted in a couple of minutes when pushed out a few meters from the shore. There was no wind in the bay, but a slight breeze over the central part of the lake caused a very slow circulation of water in the bay with a velocity of perhaps 1 or 2 cm. per second.

In contrast with this consider the phenomena observed one clear afternoon of the following April. The body of the lake was still covered with ice which was about 20 cm. thick, but close to the shore there were places where the ice had melted back for a distance of 5 meters or more. Although the air temperature was $+3°$ C. and the water 10 cm. below the surface was at $+2.5°$, ice crystals about 50 cm. long formed in these pools in less than half an hour. After considerable analysis I believe I can explain this apparent paradox by the stability in the stratification of the water in April caused by the denser underlying warm water which had been heated by the sun. With this stability which prevented vertical convection the surface water could freeze because of the radiation into the clear sky. But in December the water temperature was so uniform that the differences of density were not sufficient to prevent vertical circulation, and thus the surface could not cool to the freezing point.

It appears then that a pool of water at $+1°$ C., exposed to cold air with a slight wind can be made to freeze more rapidly if the water is heated from the bottom. Sometime I want to try this as an experiment.

All hobbies, however, stimulate individual action, and many develop wholesome curiosity. The child should acquire them early, and our educational system should foster them.

IRVING LANGMUIR

RESEARCH LABORATORIES,
GENERAL ELECTRIC COMPANY,
SCHENECTADY

JAMES CAMPBELL TODD

JAMES CAMPBELL TODD died at his home in Boulder, Colorado, the evening of January 6, 1928, following a long illness.

Born in Shreve, Ohio, March 17, 1874, he graduated from Wooster College in 1897, with a degree of bachelor of philosophy. He continued his studies in the University of Pennsylvania School of Medicine, from which he received the degree of M.D., in 1900.

While in Wooster College he held the position of assistant in biology during 1895–96. From 1900–01 he was resident physician in the Allegheny General Hospital, Pittsburgh. About this time his health failed, and he moved to Colorado, where he located in Denver.

He soon became identified in the field of medical education, first as assistant of pathology in the Denver and Gross College of Medicine during 1904–05, then as lecturer from 1905–08, later as associate professor from 1908–10, and assumed the professorship of the department in 1910.

On January 1, 1911, the University of Colorado School of Medicine absorbed the Denver and Gross College of Medicine, the two faculties were merged, and Dr. Todd became professor of pathology in the Boulder Division. He also acted as the secretary of this division until 1916. Since 1923 he has been premedical adviser in the university.

As the study of pathology broadened he felt that he was losing the contact in the fields of hematology and parasitology he desired. So in 1916 he became professor and the head of the department of clinical pathology which had just been created at his request. These positions he held at the time of his death.

During these years ill health became an increasing handicap, but in the face of these difficulties he showed a determination and persistency of purpose that won the admiration of both students and faculty. And his enthusiasm for his work was transmitted to all who had the pleasure to work with him. He was ever willing to aid, and considered the rôle of a teacher as his highest ambition.

Early in his teaching career he found that little or nothing had been compiled in clinical laboratory methods of value to the general practitioner. The collecting and testing of such laboratory procedures became his life work. He kept the viewpoint of the average medical man before him, and simplicity of technic as well as the accuracy of results claimed his closest attention.

His book "Clinical Diagnosis by Laboratory Methods" first appeared in 1908, and in the different editions he placed all his writings, with the exception of a few early articles. This book has become established over the world as an authority in its field, and it has with few exceptions enjoyed as widespread a distribution as any medical book published in English. He was sole author of the first five editions. The sixth edition, which came out in September, 1927, was written in collaboration with Dr. Arthur Hawley Sanford of the Mayo Clinic. His determination and perseverance may be realized by the fact that the work on all editions of his book was done while bedfast or in a rocking-chair.

In recognition of his ability in his field Dr. Todd was the recipient of many honors. Modest to the point of bashfulness, he would seldom speak of his own work except in a reticent manner. But his opinions on diagnostic methods always demanded respect, for they were given only after due consideration, and then in a decisive manner.

He became a fellow of the American College of Physicians in 1922, was a member of Sigma Xi, and was given honorary membership in Phi Beta Kappa by his Alma Mater in recognition of his ability and learning. He was a fellow of the American Association for the Advancement of Science, a fellow of the American Medical Association, of the American Society of Clinical Pathologists, and an honorary member of the Colorado Society of Clinical Pathologists.

Four years ago he was compelled to give up active teaching, but kept in close touch with the affairs of his department, the university and the world. He read much, not only in his particular field, but on general subjects. He will be missed in particular by his old students, and by faculty members of the university, who enjoyed his ability as a conversationalist, who admired him for his accomplishments, respected his ability and scholarship, and whose memory will be cherished as that of a man whom all could well emulate.

E. R. MUGRAGE

DENVER, COLORADO

SCIENTIFIC EVENTS

THE ARNOLD ARBORETUM

CONTRACTS for a new and larger greenhouse and nursery for the Arnold Arboretum, according to the *Harvard Alumni Bulletin,* have been signed, and work will proceed at once. The land opposite the Jamaica Plain entrance, outside the arboretum, at the corner of Center and Prince Streets, on which the greenhouse now stands, has been sold. The new site is on the South Street side of the arboretum, on the rising ground of the Bussey Institution, adjacent to the Bussey greenhouse range.

A new feature of the greenhouse will be a laboratory fully equipped for research in plant pathology and genetics. The greenhouse will be about fifty feet long, and will have, also, a workroom for potting, and pits for the growth of woody plants. The nursery, a few feet away, will cover about three acres of land.

Professor Oakes Ames, supervisor of the Arboretum and of the Harvard Botanical Museum, and chairman of the council of botanical collections of the university, made the following statement in regard to the plans for the arboretum:

> We want to make the arboretum a world center not only of systematic dendrology, but of dendrology as a whole. The proximity of the new greenhouse to the Bussey Institution will make possible a closer cooperation than has been possible heretofore. The Arnold Arboretum is the only one in the United States which is connected with a university and can draw upon the specialists in its faculty for scientific help.
>
> Already we have in view for these courses two men in the first rank in their fields, although no definite arrangements have been made to secure their services. If we succeed in getting the right man for the course in plant pathology this work will begin about July 1. Dr. East, at the Bussey Institution, will supervise the work on genetics. We shall also add to the staff another systematic botanist whose field will cover the woody plants of tropical America.
>
> The assembling of rare species and varieties of plants will be continued, of course, so that the arboretum may remain in the forefront of gardens of its type. It is expected that Dr. Joseph F. Rock, who has returned to China and is conducting explorations for the National Geographical Society, will again serve the arboretum, and will classify many of the plants which he sent us from Kansu and Tibet. This spring, Professor J. G. Jack and Alfred Rehder, of the arboretum staff, will collect new plants at the Harvard Botanical and Zoological Station at Soledad, Cuba.

The arboretum is looking eagerly toward Spanish Honduras, at present, as very little is known of its plant life because it is a difficult country for the white man to explore. It is hoped to send an expedition there in the near future, as anything found there would be exceedingly valuable from a botanical point of view.

In cooperation with the University of California an expedition will be sent this year to New Guinea. It is also proposed to send a French botanist to explore the Island of Madagascar, where there is a very interesting flora, very few specimens of which have been brought to the United States.

J. E. Palmer, of the arboretum staff, will probably go to the southern part of Texas, near the Mexican border, to add to his findings from the botanically little-known Davis Mountains.

The arboretum, although under the supervision of Harvard University, has always had to raise its own budget. During Professor Sargent's lifetime he was able through his own efforts to secure sufficient funds to meet current expenses. Since his death, the Charles Sprague Sargent Memorial Committee has been trying to raise a million dollar endowment fund to carry on the work as he outlined it. About $765,000 has been contributed to date and $235,000 is needed. Contributions, of whatever size, should be sent to the Treasurer of Harvard University, to Henry S. Hunnewell, the Cedars, Wellesley, Mass., or to William C. Endicott, 71 Ames Building, Boston.

GIFTS TO THE COLLEGE OF PHYSICIANS AND SURGEONS BY THE ALUMNI ASSOCIATION[1]

To serve as a nucleus for a fund to establish an alumni professorship of pathology in memory of Francis Delafield, P. & S., instructor in pathology and the practice of medicine at the College of Physicians and Surgeons from 1876 until his retirement in 1901, members of the Association of Alumni of the College of Physicians and Surgeons have voted to turn over to Columbia University $127,822.70 belonging to various funds of the association.

This action took place at the annual meeting of the association on January 30 at the Faculty Club. Dr. Benjamin P. Watson, professor of gynecology and obstetrics, delivered a short address comparing medical education and practices in this country with those in England.

The money for the Francis Delafield professorship is to be held in trust until by its income and subsequent gifts it reaches $200,000, the amount necessary to endow a professorship. The sum represents the principal and unexpended income of four funds—the Alumni Fellowship Fund, the Alumni Publication Fund, the Cartwright Prize Fund and the Alumni Prize Fund. In the case of the prize funds, it has been impossible for several years to award the prizes under the conditions of the original gifts because of provisions of recent postal laws which specify that if a prize is offered, a prize must be given, whether contributions merit the giving of a prize or not.

The members also voted to turn over to the university $17,601.13, representing principal and unexpended income of the Cartwright lectureship fund, to be held in trust by the university, the income to pay for lectures on medical subjects at the medical school by prominent persons nominated from time to time by the school faculty.

Dr. Francis Huber, '77 P. & S., announced that $3,000 of the Huber Building Fund was being expended in furnishing an alumni room at the new medical center. Some money will be left in the fund to meet repairs and items of additional furnishing later on.

The executive committee of the association promised the sum of $1,000, $836 of which has been raised, to renovate portraits belonging to the school before they are moved up to the new medical center.

Before transferring the Cartwright lecture fund to the university, the sum of $1,500 was set aside to pay the expenses of bringing an internationally prominent medical man to deliver an address at the opening of the medical center.

[1] From the *Columbia Alumni News*.

RADIO BROADCASTS OF TWICE-DAILY WEATHER REPORTS

FOR several months past the U. S. Weather Bureau, with the cooperation of the Navy Department, has broadcast the morning weather reports from more than 200 stations in the United States and Canada. Beginning on February 1, the complete reports, both morning and evening, will be broadcast at 8:15 A. M. and 8:15 P. M. Eastern Standard time, in cooperation with the Office of Communications of the Navy Department by distant control connection with the Naval radio station (NAA) at Arlington, Va.

The reports are expressed in the regular Weather Bureau Code which may be translated at sight after a very short study of the key to the system. These broadcasts give the widest possible distribution of the twice-daily weather reports from all parts of the country for the use of both the army and the navy, commercial and government aviation fields, business organizations and individuals who may have need of the information at an earlier hour than has been possible heretofore to release and distribute it.

Two other broadcasts are made at 11 A. M. and 11 P. M. for the benefit of European weather services. The weather reports in these broadcasts are expressed in the International Numeral Code. Information

relative to that code may be obtained on application to the Weather Bureau at Washington, D. C.—A. J. H.

DINNER IN HONOR OF DR. L. O. HOWARD

THE dinner held by the entomologists at the time of the annual meetings of the scientific societies affiliated with the American Association for the Advancement of Science, at Nashville, Tenn., during the Christmas holidays was observed as a testimonial to Dr. L. O. Howard, who recently retired as chief of the Bureau of Entomology, of the United States Department of Agriculture. Dr. H. A. Morgan, president of the University of Tennessee, who for many years was one of the leaders in entomology in the south, presided on this occasion and prominent entomologists throughout the United States and Canada paid tribute to the achievements of Dr. Howard which covered a period of nearly 50 years, during which time he has guided the entomological activities of the department, and has built up and stimulated a high degree of cooperation and good-will among the leading entomologists of the world.

Over 240 entomologists attended this dinner, representing all sections of the United States and Canada, as well as foreign countries, to express their respect and appreciation of Dr. Howard and his achievements.

A warm tribute was paid to Dr. Howard by Dr. C. L. Marlatt, the new chief of the bureau, who has been his associate for nearly forty years, in which he pointed out that Dr. Howard would continue his active research work with the bureau.

SCIENTIFIC NOTES AND NEWS

THE Geological Society of Stockholm has elected the following to corresponding membership: Professor Reginald Daly, Cambridge, Mass.; Professor Charles Schuchert, New Haven; Dr. E. O. Ulrich, Washington; Dr. F. A. Bather, London, and Professor P. Niggli, Zurich.

DR. L. H. BAILEY, of Ithaca, has been awarded the Veitch memorial gold medal by the Royal Horticultural Society of England "for scientific work on behalf of horticulture."

DR. HENRY FAIRFIELD OSBORN, president of the American Museum of Natural History, has been made a "corresponding academic" of the Italian Institute of Human Paleontology.

DR. TREAT B. JOHNSON, professor of organic chemistry at Yale University, has been appointed Sterling professor of chemistry in the university.

EDWARD BAUSCH, president of the Bausch and Lomb Optical Company, has been elected an honorary member of the American Microscopical Society "in recognition of more than fifty years of active interest in microscopy."

THE American Institute of Mining and Metallurgical Engineers has made the first award of the Hunt prize for the best paper on ferrous metallurgy by a member not more than 40 years of age to Charles H. Herty, Jr., of the United States Bureau of Mines, and the Johnson award for "the encouragement of research in ferrous metallurgy" to P. H. Royster, of the same bureau.

SIR GOWLAND HOPKINS, professor of biochemistry in the University of Cambridge, was recently presented with the Society of Apothecaries medal at a dinner.

ACCORDING to the *Bulletin* of the American Mathematical Society, the Lobachefsky prize of the Physico-Mathematical Society of Kazan has been awarded to Professor Hermann Weyl, of the Zurich Technical School, for his work as a whole and in particular for his contributions to the problems of space from the point of view of the theory of groups and for his researches on the representation of continuous groups. Earlier awards of this prize were to Lie in 1897, Killing in 1900 and Hilbert in 1903.

DR. RICHARD WETTSTEIN, vice-president of the Vienna Academy of Sciences and professor of systematic botany in the University of Vienna, has been elected an honorary member of the Russian Academy of Sciences.

PROFESSOR MANILOWSKI, who was recently appointed to the chair of anthropology in the University of London, was the chief guest at a luncheon given at the Lyceum Club on January 28 by the Polish Circle.

DR. VICTOR GOLDSCHMIDT, professor of mineralogy at the University of Heidelberg, celebrated his seventy-fifth birthday on February 10.

SIR JAMES WALKER will retire from the chair of chemistry at the University of Edinburgh at the end of the current academical year.

DR. J. PAUL GOODE, first professor of geography at the University of Chicago, will become professor-emeritus at the close of the present academic year. Professor Goode has been connected with the university since 1901.

THE seventieth birthday of Dean William Kuhns Hill, head of the department of chemistry of Carthage College, was recognized by a celebration consisting of a banquet, the presentation of a handsome chest for letters and a fireside chair presented by friends. The board of trustees have granted Dean Hill a sabbatical recess of one semester.

Drs. William J. Mayo and Alexis Carrel were guests of honor at a dinner at the Maryland Club on January 16, previous to their addressing the Johns Hopkins University School of Medicine on "The Splenomegalias" and the activities of tissue cells, respectively.

Dr. John Sundwall, professor of hygiene, public health and physical education at the University of Michigan, was elected president of the Michigan Public Health Association at its seventh annual meeting in Lansing on January 13.

Dr. Arthur P. Kelley, assistant professor of botany at Rutgers University, has joined the staff of the Allegheny Forest Experiment Station, as associate ecologist, with headquarters at the University of Pennsylvania.

Emanuel Fritz, associate professor of forestry at the University of California, has been appointed to the field staff of the West Coast Lumber Bureau, as technical authority.

Dr. T. Dwight Sloan, formerly professor of clinical medicine at the University of Nanking in China, has been appointed to succeed Colonel Louis G. Trimble as superintendent of the New York Post-Graduate Medical School and Hospital.

Alfred M. Bailey has been appointed director of the Museum of the Chicago Academy of Sciences. Mr. Bailey has been curator of birds and mammals in the Louisiana State Museum and in the Colorado Museum of Natural History.

Dr. E. Kidson, of the Central Weather Bureau, Melbourne, Australia, has been appointed to take charge of the Meteorological Bureau of New Zealand.

On invitation of Governor H. M. Towner, of Porto Rico, President Livingston Farrand, of Cornell University, accompanied by the dean of the New York State College of Agriculture, Albert R. Mann, and Dr. Lewis Knudson, professor of plant physiology, will sail for San Juan on March 1 to make a survey of agricultural conditions on the island, with particular reference to the problems of tropical agriculture and the opportunity for intensive scientific research in that field. President Farrand and Dean Mann while on the island will represent Cornell University at the twenty-fifth anniversary celebration of the University of Porto Rico.

Neil M. Judd, curator of American archeology, United States National Museum, returned to Washington on December 6, after six months' field work for the National Geographic Society at Pueblo Bonito, a prehistoric Indian village in northwestern New Mexico. The past summer marked the seventh and concluding season of the society's explorations at this most remarkable of all the pre-Hispanic pueblos of the southwest. Mr. Judd is now engaged upon preparation of his final reports to be published by the society.

Dr. George D. Birkhoff, professor of mathematics at Harvard University, is en route to Japan where he is to conduct some research work in pursuance of the mathematical principles of art.

Dr. Reuben L. Kahn, immunologist of the bureau of laboratories, Michigan Department of Health, has been invited by the health committee of the League of Nations to attend a serologic conference extending from May until July at Copenhagen, Denmark.

The Lane medical lectures, which are to be given at Stanford University by Dr. F. d'Herelle, directeur du Service Bacteriologique du Conseil Sanitaire, Maritime et Quarantinaire of Alexandria, Egypt, and discoverer of the bacteriophage phenomenon, have been tentatively fixed for the week commencing October 22, 1928. The subjects of the lectures will be as follows: "Bacteriophagy," "Bacterial Mutations," "The Nature of the Bacteriophage," "Infectious Diseases" and "The Phenomenon of Recovery." In addition Dr. d'Herelle will give a general lecture at Stanford University on "Logic in Biological Researches."

Dr. George Barger, professor of chemistry in its relations to medicine at the University of Edinburgh, whose appointment as non-resident lecturer in chemistry at Cornell University for the second term of the present university year was recently announced, will give lectures on the following subjects: The chemistry of hormones, the chemistry of vitamins, synthetic drugs, chemotherapy, the theory of the action of certain substances as depending on residual valency, illustrated by the analogy of the blue of adsorption compounds of iodine, the action of micro-organisms on carbohydrates and proteins, chemistry of sugars, proteins and purine derivatives and alkaloids.

Under the auspices of the H. K. Cushing laboratory of experimental medicine at Western Reserve University, Dr. Hugo Fricke, of Copenhagen, will give a series of fifteen lectures in biophysics at the medical school.

Dr. Sigmund Fraenkel, professor of medical chemistry at the University of Vienna, addressed the University of Wisconsin Medical Society on January 12 on "Chemistry of the Vitamins."

Dr. Bird T. Baldwin, director of the Iowa Child Welfare Research Station, will address a series of meetings in the United States and Canada during the last part of February on the subject of child development.

DR. W. F. G. SWANN, director of the Bartol research foundation of the Franklin Institute, lectured on "Recent Theories of the Atom" before the American Philosophical Society on February 3.

DR. HARRISON E. HOWE, editor of *Industrial and Engineering Chemistry,* has returned from Florida, where he was invited to speak before a number of open forums on the subject of "The New Competition."

THE centenary of the birth of Professor Eugène Koeberlé, the inventor of haemostatic forceps, has recently been celebrated at Strasbourg.

DR. CLIFFORD H. FARR, associate professor of botany in Washington University, St. Louis, died suddenly of pneumonia on February 10, aged thirty-nine years.

DR. KARL KONRAD KOESSLER, associate professor of medicine at the Rush Medical School and member of the Sprague Memorial Institute, died on February 14 at the age of forty-seven years.

DR. G. REESE SATTERLEE, specialist in gastro-intestinal diseases of the Fordham Hospital, New York, died on February 9 at the age of fifty-four years.

WADE TOOLE, professor of animal husbandry at the Ontario Agricultural College, died on January 12.

RICHARD KEARTON, well-known British naturalist, died on February 9 at the age of sixty-five years.

PROFESSOR R. W. GENESE, professor of mathematics in the University College of Wales, Aberystwyth, died on January 21, aged seventy-nine years.

GERMAN exchanges announce the death of the following scientific men: Dr. Valentin Haecker, professor of zoology and comparative anatomy at Halle; Dr. Antonin Prandtl, professor of psychology at Würzburg; Dr. Ludwig Milch, professor of mineralogy at Breslau; Dr. Richard Pribram, professor of physical chemistry at Vienna; Dr. Eilhard Wiedemann, professor of physics at Erlangen; Professor Hans Leo, formerly director of the Bonn Pharmacological Institute, and Dr. Joseph Thomayer, professor of neurology at Prague.

APPOINTMENTS to Ramsay fellowships in chemical science for this session have been made for the present session as follows, the institution selected by the fellow for his research being given: *British Fellowships:* Dr. R. F. Hunter, Imperial College of Science and Technology, London; Mr. A. M. Taylor, University of Cambridge; *Glasgow fellowship:* Mr. James D. Fulton, University of Manchester; *Canadian fellowship:* Dr. W. H. Barnes, Royal Institution, London; *Danish fellowship:* Miss Augusta M. Unmack, University of Oxford; *French fellowship:* M. Robert le Guyon, University College, London; *Italian fellowship:* Dr. Gastone Guzzoni, Royal School of Mines, London; *Japanese fellowship:* Dr. Yohei Yamaguchi, University College, London; *Spanish fellowship:* Senor Fernando Calvet, University of Oxford; *Swedish fellowship:* Mr. H. Liander, University College, London. The total value of the annual amount of the fellowships that is awarded is approximately £4,000, of which about £3,000 is provided by grants from dominion and foreign sources.

A SERIES of illustrated lectures on important developments and discoveries in various fields of engineering will be given by members of the staff of the Harvard Engineering School during the second half-year. These lectures will be open to the public, and will be given in 110 Pierce Hall on Thursday afternoons, at 4:30 o'clock, as follows: February 23.—"The Telephone and how it Works." Professor A. E. Kennelly, professor of electrical engineering. March 1.—"The Rusting of Iron and its Prevention." Professor Albert Sauveur, Gordon McKay professor of metallurgy and metallography. March 8.—"Steam Locomotives." Professor H. N. Davis, professor of mechanical engineering. March 15.—"The Purification of Municipal Water Supplies, with special reference to Cambridge." Professor M. C. Whipple, assistant professor of sanitary chemistry and sanitary inspector. March 22.—"Gasoline." Professor J. B. Conant, professor of chemistry. March 29.—"Electric and Gas Welding—One of the Most Useful Tools in Modern Industry." Professor C. A. Adams, Abbott and James Lawrence professor of engineering.

THE next International Mathematical Congress will be held at Bologna from September 3 to 10. *Nature* notes that, since the war, previous congresses have been held at Strasbourg in 1920 and Toronto in 1924, but the Bologna meeting will be the first since the war that will be strictly international in character, its two predecessors having been restricted as to membership to subjects of allied or neutral nations. The Italian prime minister takes great interest in the congress and has accepted the office of honorary president. Arrangements are actively proceeding for the various sections of pure mathematics and applications of mathematics to economics and to scientific and technical problems. In addition, excursions are being proposed for visiting the art treasures of Florence and Ravenna and some of the principal hydro-electric plants of Italy. Professor Pasquale Sfameni, rector of the University of Bologna, is organizing president, Professor S. Pincherle is president of the executive committee and the general secretary is Professor Ettore Bortolotti, Via Zamboni 33, Bologna.

THE ninetieth meeting of the German Society of Naturalists and Physicians will be held at Hamburg from September 16 to 28. Special emphasis will be given in the general meetings and in the sections to the relationships of German science and medicine to maritime studies and to overseas countries.

ACCORDING to *Nature*, the twentieth annual general meeting of the Institute of Metals will be held in London on March 7 and 8, under the presidency of Dr. W. Rosenhain, superintendent of the department of metallurgy and metallurgical chemistry in the National Physical Laboratory. The papers to be read and discussed include contributions from metallurgists in Germany, Japan and the United States, as well as Great Britain. The autumn meeting will be held at Liverpool from September 4 to 7.

THE twenty-second Dutch Congress of Natural Science and Medicine will be held at Rotterdam from April 2 to 4, 1929, under the presidency of Professor P. E. Verkade, of Rotterdam.

THE committee on scientific research of the American Medical Association invites applications for grants in aid of research on problems bearing on clinical medicine. Inquiries may be addressed to the committee at 535 North Dearborn Street, Chicago, Ill.

THE council of New York University has accepted a $3,000 annual fellowship from Sherman M. Fairchild, president of the Fairchild Aviation Company, for research in air-cooled aircraft engines by a graduate of the Guggenheim School of Aviation.

THE new $1,000,000 Chandler laboratories of Columbia University were formally opened on February 16, when members of the society of the Sigma Xi inspected them. The laboratories were built with an anonymous gift of $1,000,000 made to the university in honor of the late Professor Charles F. Chandler, who was head of the university's department of chemistry.

MAX EPSTEIN, who established the Max Epstein clinic in the University of Chicago, has given the university $100,000 to be subscribed to the building fund of the Chicago Lying-in Hospital. Mr. Epstein's contribution is to be used to establish in the Lying-in Hospital building, to be erected on the medical quadrangles, an out-patient department which shall be operated as part of the Max Epstein Clinic.

WORK will start in the spring on an addition to the University of Minnesota Hospital to cost $890,000.

ACCORDING to press reports, Albert Fuchs, Chicago millionaire, whose wife, Fanny Richter Fuchs, pianist, recently died of cancer, has announced an offer of all his wealth for cancer research. He is said to have sold his eastern holdings recently for $2,000,000.

VANDERBILT UNIVERSITY announces the gift of $50,000 from Mr. Bernard Flexner, of New York City, for the establishment of a lectureship for the purpose of perpetuating the association of his brother, Mr. Abraham Flexner, in the recent reorganization of the school of medicine. The income from this donation will make it possible to bring leading scientific men to Vanderbilt to lecture on subjects in the field of medicine and possibly allied sciences. It is to be designated as the "Abraham Flexner Lectureship," which will serve to further emphasize the interest of the university in scientific work. By special provision of Mr. Flexner in making the gift, the first series of lectures will be given during the session of 1928-29.

ACCORDING to the *Journal* of the American Medical Association, the board of trustees of St. Margaret Memorial Hospital, Pittsburgh, has received funds to establish a laboratory for clinical and biological research to be known as the John C. Oliver Memorial Research Foundation. The donor is Mrs. John C. Oliver, of Sewickley. The gift will provide generously for the equipment and maintenance of such a department in the hospital. A full-time biochemist will be in charge under the direction of a committee from the staff comprising Drs. Paul Titus, Ernest W. Willetts and Charles J. Bowen. The new department will not take part in routine laboratory work of the hospital, but will be available to the entire medical staff for research on any general medical problem.

THE contract has been let for the new $500,000 dairy building at the Iowa Experiment Station. An insectary, especially for the study of the European corn borer, was also authorized by the legislature, and a section of the new horse barn and machinery shed has been completed. The old brick horse barn will be converted into a laboratory for the department of landscape architecture, while the old dairy building will afford much-needed additional room for other departments in the agricultural division.

THE American Society of Mechanical Engineers has presented its gallery of forty-five portraits of noted engineers to Cooper Union. The gallery contains paintings of past presidents of the engineers' society. Among those represented are Charles M. Schwab, Ambrose Swasey, George Westinghouse and Admiral George F. Melville.

THE French Academy of Sciences has awarded the Le Comte donation of 50,000 francs (triannual) to Dr. Alexander Yersin, director of the Pasteur Institute, Annam.

Nature states that on March 20 the king will open the eastern block of the new buildings of the Science Museum at South Kensington. First formed in 1856,

the collections have occupied various buildings, but now for the first time they are shown in one designed for this purpose, though about a quarter of the collections still remain in buildings which were originally constructed for the exhibition of 1862.

A prize of about $250 is offered by the British *Journal of Anesthesia* for the best research in anesthesia made in Great Britain during the coming year. This will be known as the Sidney Rawson Wilson prize, in memory of the late Dr. Wilson.

The University of Edinburgh has received intimation of a bequest by the late James Sanderson, Galashiels of five shares of the residue of his estate, to be applied for the advancement or promotion in the university of technical and scientific study and research in the chemistry and engineering branches of the faculty of science. The amount of the bequest is estimated at about £35,000. The university has accepted the offer of an endowment contributed by former students and others associated with the work of emeritus Professor Robert Wallace, for the foundation of a university prize, to be known as the "Wallace Prize," to be awarded to the best degree student of the third year in agriculture.

According to the report of the Royal Magnetical and Meteorological Observatory at Batavia for 1926, recorded in *Terrestrial Magnetism,* the electrification of the Batavia-Buitenzorg railway has made it necessary to move the recording magnetographs at Buitenzorg to the Island of Kuiper in the Bay of Batavia. The plans for the new building have been completed and construction was to begin shortly.

UNIVERSITY AND EDUCATIONAL NOTES

Of an allotment of $200,000 to the school of agriculture, Pennsylvania State College, for new buildings, $150,000 is to be used for the first unit of a biology building, primarily for botany. The remaining $50,000 is to be divided between a new sheep barn, an addition to the dairy barn milk room, a livestock hospital and the first unit of a new poultry plant.

Columbia University has announced twenty-eight gifts, aggregating $25,950, including one of about $10,000 from Dr. L. M. Waugh for the purpose of financing a research expedition to Labrador.

The new Warner laboratory of mechanics and hydraulics at the Case School of Applied Science has been completed.

The Dorr Memorial Research Laboratory of Temple University was dedicated on January 31. This laboratory was made possible through a $50,000 fund bequeathed by the late Dr. Henry Isaiah Dorr.

T. R. Ferens has given a further sum of £22,500 to the newly established University College at Hull. This brings his gifts to the college to about £300,000. Mr. Ferens has asked that £20,000 of his latest benefaction should be set aside for endowing a chair. The foundation stone of the new buildings will be laid on April 28.

Dr. Charles K. Edmunds, formerly president of Canton Christian College, now Lingnan University, and later provost of the Johns Hopkins University, has accepted the presidency of Pomona College. He will assume office about May 1.

Dr. Madison Bentley, of the University of Illinois, has been appointed Sage professor of psychology at Cornell University to occupy the chair held for nearly thirty-five years by the late Edward Bradford Titchener.

Dr. Edward U. Condon, recently an International research fellow in mathematical physics at Göttingen and Munich and at present a special lecturer in Columbia University, has been appointed assistant professor in physics at Princeton University.

Dr. P. W. Whiting, for the past year research investigator under the National Research Council stationed at the Bussey Institution, Harvard University, has been appointed assistant professor of zoology at the University of Pittsburgh.

Albert H. Gilbert, assistant professor of botany at the University of Vermont and associate plant pathologist for the Vermont Experiment Station, has been appointed professor of plant pathology and head of that department at Macdonald College, the Agricultural College of McGill University.

A. C. Hardy has been appointed the first professor of zoology at University College, Hull, England. Mr. Hardy acted as zoologist to the recent expedition to the Antarctic in the *Discovery*.

Dr. Emil Ritter von Skramlik, of Freiburg, has been appointed professor of physiology at Graz.

DISCUSSION AND CORRESPONDENCE

THE ICHNOLOGY OF TEXAS

It it is almost one hundred years since the Reverend Dr. Duncan initiated the subject of ichnology by the description in the *Transactions of the Royal Society of Edinburgh* of some genuine tracks in the New Red Sandstone of Scotland. During the century that has passed there have been many contributions to the subject, and the last two years have been especially fruitful of studies, both in America and in Europe. Interest in these fascinating objects does not wane, but rather seems to be on the increase, in spite of the

opinion of paleontologists that the study of tracks "leads nowhere," and "are so blind." To a true paleophilist fossil footprints are notes from the life of the animals of the past and give us some clue, not otherwise obtainable, of their daily life. The evidence is slight, it is true, but none the less the study of footprints aids us in our understanding of paleobiology, which we could not otherwise have.

Feeling thus as I do about the study of footprints, it was a source of delight to find here on the Pacific Coast other paleophilists who felt the same about the matter, and they possessed a collection of fossil footprints from the Red Beds of Texas, which I suggested would be well worth studying. The collection was then placed at my disposal. The tracks all represent small animals of types which are unknown from skeletal material. Williston saw some of the tracks in 1909 and suggested they might represent salamanders. During the twenty years which have elapsed since Williston published his short note, small collections of these objects have accumulated in several museums, and the time seems propitious to gain an insight into the small animals of the famed Texas Red Beds, by a study and description of this assemblage of new materials. The several hundred tracks represent a variety of animals, all of which are new to science.

We shall accept it as a well established matter that the usual rules of taxonomy apply to ichnological objects. This is a commonly accepted opinion of paleontologists and needs no defense. There are several new species, of different genera, represented in the present assemblage which it is planned to define as well as may be and place the matter where it can be at the disposal of other workers. The majority of the tracks measure under 15 mm. in length, the imprints looking amazingly like the foot-structure of the Microsauria whose anatomy I so delighted to study ten years and more ago. In addition to the vertebrate impressions, and making the study more fascinating still, are the trails of invertebrates and weather indications.

It has been more than a century since Pliny Moody pointed out to his friends the footprints of *Noah's Raven* on the red slab which formed a doorstep to his home in Massachusetts, and it is my purpose to regard this study of the Ichnology of Texas as a centennial celebration of man's study of the trails of his predecessors. It is my hope to see and study all materials of this nature and I hope that those who read this note and know of footprint assemblages from Texas will be so courteous as to let me know.

Roy L. Moodie

1021 Eleventh Street,
Santa Monica, California

DISCOVERY OF FOSSIL TRACKS ON THE NORTH RIM OF THE GRAND CANYON

Fossil tracks of quadrupedal animals were first discovered in the rocks of the Grand Canyon of the Colorado in 1915, but the abundance of their occurrence and their great variety of kind has only recently been made known.[1] During the past three years investigations carried on by the senior author show the presence of no less than 28 genera and 36 species of fossil ichnites. These represent three distinct faunas that named in descending order occur in the Coconino (Permian), Hermit (Permian) and Supai (Pennsylvanian?) formations. All of the specimens on which the above-mentioned determinations are based were obtained entirely from the south side of the canyon, and it is, therefore, of interest to find that fossil footprints also occur on the north side. Mr. Sturdevant, with the assistance of Mr. Charles Nash, made a special search for tracks on the north rim and on December 9, 1927, and was rewarded by finding well-preserved footprints in both the Coconino and Supai formations.

When collections have been made, it will be a matter of added interest to learn whether the tracks occur in the same horizons and also whether the same genera and species are to be found on both sides of the canyon, which are separated by a distance in an air line of fourteen or more miles.

Charles W. Gilmore,
U. S. National Museum
Glenn E. Sturdevant,
Grand Canyon National Park

A CORM ROT OF GLADIOLUS CAUSED BY A PENICILLIUM

The diseased corms have reddish brown lesions, firm but not hard, sunken, usually irregular in size and shape and without definite margins. The dark brown, moderately porous rot invades the corm tissues rather rapidly at temperatures between 12 and 23° C., eventually destroying the corm. At temperatures above 20° C. there is but scanty development of the blue-green conidia. Numerous sclerotia appear both on the surface and in the interior of the attacked corms.

The pathogenicity of the fungus has been proved by inoculation experiments and the connection of the sclerotia with the Penicillium has been definitely established.

[1] Gilmore, C. W., *Smith. Miscel. Coll.*, Vol. 77, No. 9 1926, pp. 1–41, 12 plates; *Smith. Miscel. Coll.*, Vol. 80, No. 3, 1927, pp. 1–78, 21 plates; *Smith. Miscel. Coll.*, Vol. 8, No. 8, 1928, pp. 1–16, 5 plates.

Both growing and stored corms become infected through even slight wounds but the fungus seems unable to penetrate the uninjured epidermis of corms.

Technical Description: Penicillium gladioli n. sp.

When grown at 20–24° C. on gladiolus corms or on favorable media such as Czapek's solution agar, or potato dextrose agar, the conidiophores are 50 μ to 2 mm. long by 2 to 3.6 μ in diameter; penicillus consisting of the main axis of the conidiophore with or without one or two branches, bearing few metulae 10–12 μ long and verticils of few sterigmata 12 to 14 by 1.5 to 2 μ with tapering rather than acute points, and conidia elliptical-fusiform, smooth, hyaline, 2.8 to 3.6 by 2.5 to 3 μ, adhering in long chains. When grown at 10 to 16° C. the conidiophores tend to be longer and coarser, with walls pitted or roughened, often forming conspicuous tufts, fascicles or complex branching coremia.

The sclerotia are 140 to 540 μ in diameter; cream to light pinkish tan, in age becoming pale brown or tan; smooth and composed of thick-walled cells 8 to 12 μ in diameter; retaining their vitality for several months.

On Czapek's agar the reverse color of the fungus growth is light pinkish cinnamon; drops of pale orange yellow fluid are more or less conspicuous on the mycelium; odor none.

The fungus described above has been identified from corms grown in such widely separated regions as Holland, New Mexico, Canada, Kansas and New York.

LUCIA McCULLOCH
CHARLES THOM
U. S. DEPARTMENT OF AGRICULTURE,
WASHINGTON, D. C.

UNDULANT FEVER IN AMERICA

IN 1906 Craig[1] reported the first case of Malta (Undulant) fever originating in the United States. At the close of his paper he states: "(1) The probability of much wider distribution of Malta fever, even in temperate climates, than is generally supposed, and therefore the great importance of applying the serum test in all undetermined cases of fever in all regions. (2) That there are no pathognomonic symptoms of Malta fever. All the symptoms presented may occur in many other infections, and the cases are very few in which a diagnosis can be made without the aid of the serum reaction." The increasing number of cases reported since that time shows that Craig's prediction was correct.

The observation that the causal organism of Malta fever (*Alcaligenes melitensis*) and contagious abortion (*Alcaligenes abortus*) in cattle are closely related in their cultural, biochemic, serologic and pathogenic characteristics was reported by Miss Evans[2] and has been confirmed by numerous investigators. In addition to goats and cattle, hogs and horses are known to harbor the microorganisms.[3]

Of 35 strains studied by Miss Evans[3] 33 were of the abortus or melitensis A varieties. One strain which did not conform to the two common varieties is serologically closely related to paramelitensis of Négre and Raynoud.[4] These authors designated as paramelitensis in their morphologic, cultural and biochemic features, but failed to agglutinate or agglutinated slightly in melitensis serum. Absorption of agglutinins by paramelitensis from melitensis serum was only partial.

The writer has recently isolated a microorganism from the blood of a patient ill with a wave-like type of fever of long duration; with swelling and painful joints and sweats. Blood examination showed secondary anaemia, leucopenia and a marked increase in the percentage of the lymphocytes.

This microorganism was culturally, morphologically and biochemically melitensis, but it agglutinated in melitensis serum in the lower dilutions only, and it did not absorb very much of the agglutinins from the serum. Spontaneous agglutination in salt solution was marked. Perhaps this variety of melitensis is more widely spread than was formerly believed.

FREDERICK W. SHAW
MEDICAL COLLEGE OF VIRGINIA,
RICHMOND

[1] Craig, Chas. F., *Internat. Clinics*, 15 ser., 4, 115, 1906.

[2] Evans, Alice C., *Jour. Inf. Dis.*, 22, 580, 1918.

[3] Evans, Alice C., *Hygienic Lab. Bull.* no. 143, 1925.

[4] Négre, L. and Raynaud, M., *Compt. rend. Soc. de biol.* Paris, 72, 791, 1912.

ARE SALT SOLUTIONS MUSICAL?

TESTS in our laboratory with magnesium sulphate, salt, ammonium chloride and sugar convinced us that the change in pitch described by Dr. C. D. Spivak (SCIENCE, October 21, 1927) is due almost entirely to a change in volume of the solution with a consequent change in the length of the resonant column in our closed tube (air column over liquid in tumbler, beaker or graduate). Thus when magnesium sulphate is added to water the first increase in volume is equal to that of the dry magnesium sulphate; but as solution progresses, the volume of solution plus solid diminishes with a corresponding change in pitch. Solids on the bottom of the container produce a deadening of sound. The addition of sand deadened the sound and caused a change in pitch equal to that caused by the addition of an equal volume of water. I wonder if Dr. Spivak has taken these points into

consideration? His finding that some salts are non-musical can be explained in this manner. If the length of the resonant column is long, the addition of salt or solid to the liquid below will cause only a relatively small change in the length of the resonant column. If, on the other hand, it is short to begin with, and has its length decreased by one half, a change of one octave will occur.

O. C. MAGISTAD

UNIVERSITY OF ARIZONA

BANANA STOWAWAYS

SOME time ago a couple of strange "mice" with prehensile tails, were brought to the laboratory from a neighboring grocery store. They proved to be Marsupials from some one of the Central American States, and belong to the genus Marmosa sp. A visit to the store resulted in the discovery of three more of this marsupial family making five in the single bunch of bananas. They were fed on grasshoppers and bananas and lived until the cold weather came on, when proper food could be secured no longer.

Many animals are imported in banana bunches and many insects, snakes and rats have been collected in the fruit commission houses, but this is the first time in the writer's knowledge that Marsupials of this genus have been included in the list of stowaways.

L. A. ADAMS

UNIVERSITY OF ILLINOIS

ON THE VELOCITY OF SOUND

IN an article entitled as above and published on page 381 of SCIENCE for October 21, 1927, an error was made in the value of a constant in the last line of the article. This line should read

$$V = 331.4\left(1 - \frac{4.45 \times 10^{-3}}{d\,n^{.58}}\right)\frac{\text{meters}}{\text{sec}}$$

P. I. WOLD
GEO. R. STIBITZ

UNION COLLEGE

SCIENTIFIC BOOKS

Navigator. The Story of Nathaniel Bowditch. By ALFRED STANFORD. New York: William Morrow & Co. pp. 308. $2.50.

IT is only an occasional book in the field of general literature that threads its story about the life of a scientific man. When such a contribution comes from the press it is a pleasing diversion from the technical aspects of one's subject and even from the more conventional types of scientific biography. Such a book is "Navigator" by Alfred Stanford, a recent Amherst graduate.

To one who is interested in things of the sea and the nautical aspects of a brilliant career this novelized sketch of the earlier days of Nathaniel Bowditch, of Salem, will prove a pleasing book.

It is more than a narrative of events in the life of a singular man. It is a book that wrests from the obscurity of eighteenth century science, a reticent but extraordinary personality.

To all who "go down to the sea" in ships, the name Bowditch is tantamount to Hoyle and "The American Practical Navigator" originally by Nathanial Bowditch is the recognized American epitome on navigation which has for so long been printed and reprinted by the Hydrographic Office that the number of its editions is now almost legion. If the aim of Mr. Stanford's book had been to show how and why this celebrated epitome of navigation came to be written, he could not have more strikingly portrayed his character, but his aim has been more than this. It is obvious that the author has solicited a wider circle of readers than mathematicians and astronomers by making human his unique character and detailing his varied experiences rather than his mathematical contributions.

Those who knew Bowditch more seriously through the authentic memoirs or the traditions of Salem's nobility, may find not altogether pleasing the intimacies of imagined conversations or descriptions of conjectured conduct, yet it is surprising and indeed gratifying, to find how consistent with fact is the main artery of events in this kaleidoscopic picture.

So far as the problems of the eighteenth century are concerned, Stanford has shown himself well informed. A scientific mind cringes a bit at the indiscriminate use of "straight line" for a "great circle" course to shorten sailing distances and the spelling of Laplace's celebrated work as "Mechanique Céleste." One might moreover gain the impression that a ship's position could be determined from lunar observations with a far greater degree of accuracy than was ever achieved in practice.

On the other hand, one should not minimize Bowditch's notable contribution to "lunars" in a day when chronometers were scarce and often wanting entirely in a ship's navigating equipment. While the author may have played up (or down) to romance with all allowable license in a book purportingly founded on fact, he has not obscured the Salem lad's love of figures as the *motif* of his career, nor has he failed to make mention of the high honors gained by his mathematical and astronomical attainments.

The final chapter is indeed a dramatic ending, and the more captivating for the knowledge that it is substantially according to fact. Rumor states that Captain Bowditch gained one glimpse of shore or of a familiar coastal light that piloted his landfall on the

stormy return of the *Putnam* to Salem. Like Lindbergh's flight to Paris, aside from a piece of good navigating ability, it was probably a piece of good luck as well, that made possible the spectacular arrival. One might gain the impression that Bowditch's happy landfall was made possible by the accuracy of his newly developed "lunars," which, of course, is much overdoing it. Such a criticism is perhaps trivial for a book of much dramatic value, of distinctly human interest in things scientific, and perhaps on the whole as delightfully written as any fictional biography of the day. One can but wish equally competent authors would explore the fruitful and relatively untouched field of science for recreating in the literature of the day great personages of the past.

H. T. STETSON

HARVARD ASTRONOMICAL LABORATORY

REPORTS

AMERICAN SCHOOL OF PREHISTORIC RESEARCH

IN certain respects the work accomplished by the American School of Prehistoric Research in 1927 marks a departure from preceding years. In addition to the regular program there were four prospecting parties in the field. Moreover, during the term, the group of students was successfully turned over twice to former students of the school.

RECONNAISSANCE

Southern France.—The prospecting trip by the director and Mrs. MacCurdy was in southern France: the cavern of Aldène at Fauzan near Olonzac (Hérault); the Grottes des Fées on the Pic d'Ambouls near Nant (Aveyron); and the much discussed site known as Glozel near Vichy (Allier). Aldène is one more of the many caverns in southern France on the walls of which Paleolithic man left examples of his art; these were discovered in February, 1927. It has also yielded remains of Neolithic man including fine examples of pottery. The Grottes des Fées near Nant may also have been the abode of man in both Paleolithic and Neolithic times, but as yet only Neolithic remains have been discovered. As for Glozel, the prehistoric problems it has forced upon the attention during the past three years are now up for solution before an International Committee.[1]

Rumania.—One of our students, Dr. V. J. Fewkes, of the University of Pennsylvania, spent a part of June exploring a group of caves in the vicinity of Steierdorf, Rumania.

Austria.—Under the auspices of the school, a party in charge of Dr. Kurt Ehrenberg, of the University of Vienna, explored the newly discovered *Schreiberwand* cavern on the Dachstein mountain near Salzburg.

Greece.—After the close of the summer term, two of the students spent a month in Greece with a view to the checking up of prehistoric collections and sites.

SEVENTH SUMMER TERM

The seventh summer term of the school opened in London on June 27 and closed in Cologne on September 15. The special fields covered were southern England; a section of the Somme valley in the region of Amiens; Paris and St. Germain; Brittany; the region of Civray (Vienne), where the members of the school dug for a week as the guests of Mr. James T. Russell, Jr., a former student of the school; Charente; Dordogne with a season of digging at Castel-Merle near St. Léon-sur-Vézère and local excursions to important prehistoric sites and museums; an excursion to the caverns of Ariège and Haute-Garonne on the invitation of Count Begouen; Altamira, northern Spain; Neuchâtel, Zurich, St. Gallen, and Bâle, Switzerland. Attendance at the annual meeting of the German Anthropological Association marked the close of the term.

SUMMARY

Of the eleven students taking part, about half were unable to remain for the entire term; these were permitted to join for short periods. In addition to the student body, permission was granted thirty-four other persons interested in our work to take part in our program—especially in Brittany and the Dordogne.

Of the fifty conferences given, twenty were by the director and thirty by twenty-eight specialists. To the latter, the director desires to express his deep sense of appreciation. Sixty-three important prehistoric sites and thirty-five museums and special collections were examined. As a result of the twenty-five days of digging, collections were sent to seven contributing institutions. At the end of the season five students remained in the Old World for further study and field work.

PROSPECTS AND NEEDS

The school has demonstrated its ability to give a limited number of students intensive training in prehistoric archeology during the summers. It should be able to follow up these short periods of intensive training by taking the initiative in the location and development of new projects either alone or in cooperation with other existing institutions. During the

[1] This committee has since reported against the authenticity of the Glozel specimens.

past summer, invitations have come to us from members of Oxford University and the British School in Jerusalem to cooperate with them jointly in prehistoric exploring expeditions both in Iraq and in Palestine. Such a program renders highly desirable not only permanent headquarters for the school but also adequate endowment and if need be special funds for special projects.

With a permanent base, preferably at home, serving as a laboratory and repository for apparatus, books and specimens, branch bases could be established, or existing ones made use of, on the other side as the occasion demanded. With adequate endowment, professorships and lectureships might be maintained, at least one of which should be for distinguished foreign specialists. We already have the promise from an able foreign prehistorian and ethnologist that he will come to America and offer gratis a course of lectures as soon as such a center shall have been established. Surely we can not afford to be so lacking in appreciation of such a generous offer as to fail to take advantage of it.

BULLETINS

During the year two bulletins have been published by the school: Bulletin 2 containing the minutes of the first meeting of incorporators and trustees, the certificate of incorporation, and the by-laws of the school; and Bulletin 3 containing the report of the director on the work of the sixth season (22 pp. and 26 figures).

GEORGE GRANT MACCURDY

YALE UNIVERSITY

SPECIAL ARTICLES

ON THE DISTRIBUTION OF CRITICAL TEMPERATURES FOR SPAWNING AND FOR CILIARY ACTIVITY IN BIVALVE MOLLUSCS*

I

ORTON[1] classifies marine animals into three groups: (a) those which breed at a definite temperature, which is a constant for the species throughout its range; (b) those which breed at a particular temperature change, which may be at either the maximum or the minimum for the locality; (c) those which breed the year round.

Observations of the spawning temperatures of lamellibranch molluscs show that they fall within the first of these groups. Data gathered from the literature and collected by myself during some ten years of study of the marine lamellibranch larvae of our coastal waters show that of those bivalve molluscs which have been investigated each has its critical temperature for spawning. No species other than the American oyster has been studied extensively enough to determine the duration of the latent period after the critical temperature is reached before spawning begins. Since spawning occurs on a rising temperature in all forms thus far studied, it follows that the actual "trigger" temperature for these species is probably slightly below that of the water in which the first larvae are found.

The following species with their spawning temperatures represent those molluscs the larvae of which I have found, together with spawning temperatures gathered from the literature.

4– 5° C.	An as yet unidentified larva which appears in Barnegat Bay early in March.
10–12° C.	*Mytilus edulis, Mya arenaria, Astarte, Venericardium, Nucula.*
15–16° C.	*Ostrea edulis* (Orton[1]), *Ostrea lurida, Pecten irradians* (61.5° F. Belding[2a]), *Teredo navalis.*
20° C.	*Ostrea virginica* (J. Nelson[3], Townsend[4], Moore[5], Stafford[6], T. Nelson[7b], Churchill[8], Prytherch[9]).
24–25° C.	*Venus mercenaria* (76° F. Belding[2b]; 25° C., my finding). *Mytilus recurvus.*

One is impressed by the fact that these spawning temperatures fall into groups which differ by approximately 5° C. Setchell[10] studying the temperature limits for growth and fructification of marine algae, marine spermatophytes, and land plants has been led to assign as critical temperatures for the initiation of these processes: 5°, 10°, 15°, 20°, and 25° C. Crozier[11] has brought together a large amount of data on the temperature characteristics of vital processes of the most diverse sorts, and from these and other

* Publication No. 11, N. J. Oyster Investigation Laboratory.

1 Mar. Biol. Assoc. XII, 339, 1920.

2 Report upon the Scallop Fishery of Mass., 1910; (b) Report upon the Quaghog and Oyster Fisheries of Mass., Boston, 1912.

3 Report N. J. Exp. Sta. for 1890, 314; Contr. to Canad. Biol. for 1915–16, 53.

4 Report U. S. F. C. for 1889–91, 343.

5 Doc. 610, U. S. F. C., 1907.

6 The Canadian Oyster, Ottawa, 1913.

7 (a) Report N. J. Expt. Sta. for 1920, 317; (b) Bulletin 351, N. J. Exp. Sta., New Brunswick, 1921; (c) *Proc. Soc. Exp. Biol. and Med.* XXI, 90, 1923; (d) SCIENCE, LXIV, 72, 1926.

8 App. VIII, Report U. S. F. C. for 1919.

9 App. XI, Report U. S. F. C. for 1923.

10 *Am. J. Bot.* XII, 178, 1925.

11 *J. Gen. Physiol.* IX, 525, 1926.

data he determines the critical points to occur most frequently in the neighborhood of 4.5°, 9°, 15°, 20°, 25°, 27° and 30° C. As he points out, the agreement of these figures with those of Setchell can hardly be accidental. It may be assumed, therefore, that the temperatures for spawning of the lamellibranchs here listed fall where they do by reason of similar fundamental processes which control vital phenomena in the plants and animals considered by Setchell and by Crozier.

II

Although spawning has been the most extensively studied in relation to temperature of all vital processes in bivalve molluscs, observations of ciliary activity made thus far on lamellibranchs reveal a similar distribution of critical temperatures. Gray[12] showed in *Mytilus edulis* a progressive increase in speed of the cilia, with normal amplitude of beat, from 0° to 32.5° C. One may take 0° C. therefore as the critical temperature for the initiation of ciliary activity in this form.

In *Ostrea virginica* I have shown (Nelson, T. C., a, c, d.) that the critical temperature for ciliary activity and for shell opening of animals taken during cold weather is close to 5.6° C. Below this temperature ciliary activity is practically in abeyance. Galtsoff[13] finds that the cilia of the oyster come to a standstill at 5° C. This critical temperature of 5° for ciliary activity is accompanied by a spawning temperature of 20° C. Roughley,[14] working with the Australian oyster, *O. cucullata,* has shown that this form fails to open in water of a temperature lower than 10° C., whereas above this point the molluscs are active. This observer also notes that pulsations of the heart become slow and weak at 10° C. while above this temperature the beats are vigorous and more rapid. The spawning temperature for this species is not known, but from the restricted distribution of *O. cucullata* and from the observation of Roughley that in some seasons it does not spawn at all in the northern part of its range, it is probable that its spawning temperature will be found to be either 20° or 25° C.

Of interest in this connection is the observation of Takatsuki[15] that the pulsation of the heart of *Ostraea circumpicta* is abolished at 0° C. but begins at 5°–7° C. It is hoped that future work at the Asamushi Station will establish the critical temperatures for spawning and for ciliary activity in this little known species of oyster.

[12] *Proc. Roy. Soc.* 95, 6, 1923.
[13] SCIENCE, LXIII, 233, 1926.
[14] *Proc. Linn. Soc. N. S. W.*, LI, 446, 1926.
[15] *Scientific Report,* Tokhoku University, 4th Ser., II, 3, 1927.

The bearing of critical temperatures upon the distribution of these lamellibranchs is of prime importance, but can not be discussed here further than to mention the following facts. *Ostrea virginica,* the most valuable mollusc in the world, is barred from most of the otherwise favorable coast lines of the earth since the waters there rarely attain a temperature of 20° C. for a sufficient period to permit spawning. The inferior species *O. lurida* and *O. edulis* may thrive there since much of the coastline of the northern hemisphere rises to 15° C., or slightly above, for the time necessary to permit these species to spawn. *Teredo navalis* with the same spawning temperature has been carried into most of the ports of the world. *Mytilus edulis* with its still lower spawning temperature is the most widely distributed marine lamellibranch in the northern hemisphere. *Venus mercenaria,* the hard clam, on the contrary, is found only in a relatively few sheltered areas where subtropical spawning temperatures of 25° C. are attained at some time during the summer.

Many more observations of other species of pelecypods in widely different environments are needed to determine whether the critical temperatures shown above are characteristic for this group of animals as a whole. This preliminary paper is presented with the suggestion that study of the spawning temperatures of groups of aquatic species in the light of our newer knowledge of critical temperatures will prove a valuable method of attack upon problems concerning the distribution and behavior of such organisms.

THURLOW C. NELSON
RUTGERS UNIVERSITY

STARVATION KETOSIS OF THE PRIMATES

IN the course of experimental work on monkeys afflicted with "cage paralyses" the writer found that they excrete relatively large quantities of acetone bodies when starved, and, by analyzing the data in accordance with the ketogenic-antiketogenic conceptions of Shaffer,[1] the excretion (with the exception of the lemur) could be considered comparable in every way to that of man.

The following animals were used:

Black ape, *Cynopithecus niger* (Desmarest) (Celebes), male and female;

Bonnet Macaque, *Pithecus sinicus* (Linn.) (India), male and female;

Brown capuchin, *Cebus capucinus* (Linn.) (South America), male.

A mandrill, Papio sphinx (Linn.) (West Africa), male, on starving was found to excrete only traces of

[1] Shaffer, P. A., The Harvey Lectures (Series XVIII), Lippincott, 1924.

acetone bodies. The nitrogen excretion during starvation, however, was extraordinarily high. The animal weighed 5 Kg. and normally excreted 1.3–2 g. of nitrogen per day. After the withdrawal of food the nitrogen excretion rose to 4.5–5.3 grams per 24 hours on the three days of starvation.

A lemur *Lemur macaco* (Linn.) during two starvation periods of four days each excreted only faint traces of acetone bodies and the nitrogen excretion increased only slightly.

The animals were placed in metabolism cages and urine collections were made (without catheterization) at frequent intervals. The animals were very quiet, and would move away only when touched or frightened; however, they readily ate food when offered. They appeared to be in good condition—not noticeably emaciated. The urine contained much acetoacetic and β-hydroxybutyric acids after 24 hours starvation, and the excretion of these acids reached its maximum after 48 hours. The ketosis was promptly abolished on feeding glucose or carbohydrate-rich foods.

It will be noted that the starvation ketosis was equally severe in both the new and old world monkeys, and since it was found in monkeys of differing genus and living in widely separated regions, this behavior is believed to hold true for the anthropoidea in general. It is particularly interesting that a marked starvation ketosis has been observed only in the case of man and the anthropoidea. Thus a survey of the literature shows that the following do not develop a marked ketosis: dairy cow, steer, goat, pig, cat, dog, rabbit, guinea pig, rat.

There appears to be a real difference in the fat metabolism of man and the monkey on the one hand and the other animals enumerated above. It can not be explained by dietary habits, since it has been found to be slight in both carnivora and herbivora; nor can one accept the theory advanced by some that the absence of a starvation ketosis is due to adaptation. According to the popular theory fat metabolism proceeds in steps by β-oxidation, resulting finally in one of the acetone bodies, probably acetoacetic acid. The difficulty lies in the disposal of the latter. It is more logical to assume that organisms in general possess the means of *completely* metabolizing fats which are natural and necessary components of the cell. Putrefactive bacteria for example readily metabolize acetoacetic acid (Neuberg). The cat[2] and the dog[3] have a high tolerance and readily dispose of intravenously administered acetoacetic acid. The high tolerance and absence of a marked starvation ketosis is perhaps due to the presence of a "ketolytic" enzyme or catalyst which enables the cell to dispose of the acetoacetic acid formed from fat, etc. Entire loss or disfunction of this cell catalyst results in a ketosis. In the course of evolutionary development of the primates the "ketolytic" cell catalyst appears to have been lost. The acetone bodies do not normally appear in man because of a peculiar adaptation in which it appears that "the fats burn in the fire of the carbohydrates." Lacking metabolizable carbohydrate (as in starvation, phlorhizin diabetes, diabetes mellitus) the primates can not burn acetone bodies because of the absence of the ketolytic ferment. Because of the ease with which the lower animals dispose of acetone bodies they do not need to burn acetone bodies "in the fire of the carbohydrates," and metabolizing carbohydrate therefore probably is not antiketogenic, as in the case of the primates, because the necessary enzymes are not present. The slight starvation ketosis observed in the case of the lower animals, therefore, is not to be considered due to a lack of metabolizable carbohydrate, but is due rather to an altered condition of the cell which results from the low carbohydrate content. Restoration of the carbohydrate content of the cell to normal allows the cell to more efficiently burn the fats and hence leads to disappearance of the slight ketosis.

It is interesting in this connection to note several instances of severe ketoses, without apparent loss of carbohydrate tolerance, observed in cows. Sjollema and Van der Zande[4] report an "acetonaemia," etiology unknown, in milch cows following parturition. Although the animals received food, glucose was absent from the urine and the blood sugar was normal. A similar condition seems to occur in cattle poisoned by white snake root *Eupatorium urticaefolium*. From the meager data at hand, it appears that the carbohydrate metabolism in this condition also is not markedly disturbed. If a further study should confirm these observations, one may hazard the guess that the ketosis is due to blocking or a disfunction of the ketolytic ferment or hormone. A ketosis, in spite of a normal carbohydrate metabolism would confirm the view advanced above that glucose in these animals is not antiketogenic.

Theodore E. Friedemann

Department of Biological Chemistry,
Washington University

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SCIENCE NEWS

Science Service, Washington, D. C.

ENGINEERING AND THE EVOLUTION OF SOCIETY

IN man himself, and in his behavior as a unit in the great superorganism into which society is developing, lies the chief obstacle to future social evolution. This was the keynote of an address given in New York on February 15 by General John J. Carty, vice-president of the American Telephone and Telegraph Company, in accepting the John Fritz Medal of the American Institute of Electrical Engineers. Only by adequate support of scientific research, he declared, can the human obstacle be surmounted.

"If seeking the truth and applying the truth to the affairs of men, is a spiritual thing, then the engineer must be absolved from the charge of materialism," said General Carty. "He is an advocate for truth. His works must be tried in the inexorable court of nature, where no errors are committed and no exceptions granted. The work of the engineer is dedicated to the use of mankind, and the pecuniary compensation which he himself obtains is slight compared with the great benefits received by society."

Future evolution of present-day man into a superman, even if it should occur, will be too slow to be of any immediate benefit. There is another kind of evolution that is preeminently under the control of the engineer. Quoting Professor E. G. Conklin, Princeton University biologist, General Carty pointed out that "the evolution of man, the individual, is no longer limited to his body or mind; but by adding to his own powers the forces of nature, man has entered upon a new path of progress. The differentiations of various members of a colony of ants or bees are limited to their bodies and are fixed and irreversible. But in human society, differentiations are no longer confined to the bodies of individuals. Although he is not as strong as the elephant, nor as deft as the spider, nor as swift as the antelope, nor as powerful in the water as the whale, nor in the air as the eagle, yet by his control of the forces of nature outside his body, man can excel all animals in strength and delicacy of movement, in speed and power, on land, in water and in air.

"The true object of engineering is not to create machines to which man would be bound by the chains of necessity, or mechanisms to which they would become slaves. The mission of the engineer is to obtain such a mastery in the application of the laws of nature that the forces of the universe will be employed in the service of man.

"The use of the spoken word to convey ideas distinguishes man from all other created things. It is the function of the engineer to provide for the extension of the spoken word by means of electrical systems of intercommunication which will serve to connect the nervous system of each unit of society with all the others, thus providing an indispensable element in the structure of that inconceivably great and powerful organism which I believe is to be the ultimate outcome of the marvelous evolution which society is to undergo.

"There is one element, and only one, which stands in the way of the realization of this inspiring vision. That is man himself, for he is the unit or cell out of which the new organism is to be evolved.

"Already, the applications of science to human affairs have far outrun the ability of man to use them wisely. The engineer has provided agencies of incalculable value in time of peace, but they are also endowed with prodigious powers of destruction which can be loosed in time of war. Unless we solve the problem encountered in man himself, the outlook is dark indeed, and it may even be questioned whether our civilization will endure. Human behavior presents the most formidable and the most important problem of all the ages. Its solution can be achieved only by concentrating upon it all of the knowledge and wisdom and resources at the disposal of man."

GEOPHYSICAL EXPLORATION FOR ORES

PROBING into the depths of the earth, inaccessible to the miner's eye or drill, the geologist is now determining the location of valuable oil and minerals through the use of instruments and methods that up to a few years ago were not known outside of scientific laboratories.

Engineers, gathered in New York City for the sessions of the American Institute of Mining and Metallurgical Engineers, discussed the application of these modern "divining rods" to the discovery of new mineral riches.

Gullible miners and landowners have been fooled and humbugged in past years by unscientific diviners who claimed to be able to locate hidden oil, coal and minerals by rods or devices that they held in their hands. Farmers have hired these rural mystics to determine where to dig wells. Such methods of prospecting have been discredited. Through the use of the principles of physics, however, the geophysicist has realized the wishful claims of the impostors and now by an array of complicated instruments can advise the mining engineer where to drill or dig in order to try for oil or metal.

Prospecting by geophysical methods is possible because the rocks and other deposits in the earth have different physical properties which can be detected by suitable apparatus at the surface, according to Dr. Hans Haalck, scientific expert for German and American exploration companies, speaking before the meeting. Geophysical prospecting is now possible practically by gravimetric, magnetic, seismic and electric methods.

Masses of light or heavy materials within the earth affect the gravitation of the earth nearby and can be detected with a pendulum, or gravity balance, like the Eotvos torsion balance. Such information about internal

NEW SCIENTIFIC BOOKS

George Routledge and Sons, Limited, London

An Introduction to the Theory and Use of the Microscope. C. R. Marshall and H. D. Griffith. 32 illustrations. pp. viii + 90.

It is expected that this book will prove of value to all students who require a microscope as well as to those amateur microscopists who desire to understand the fundamental principles on which microscopy is based. There is a chapter on the elementary mathematical treatment of certain problems.

E. P. Dutton and Company, New York

Thermionic Phenomena. Eugène Bloch. viii + 145. $2.50.

A summary of our knowledge concerning the emissions from heated bodies. The value of the book is increased by a chapter giving an account of some of the applications of thermionic phenomena.

Ginn and Company, Boston

Education through Manual Activities. Anna M. Wiecking. pp. vi + 351. $1.80.

This book is designed for teachers of kindergarten and primary grades and should also have an interest for parents from the point of view of its bearing on home play and the employment of leisure.

The Peking Union Medical College, Peking, China

Bibliography of the Publications of the Peking Union Medical College and Hospital.

This includes all the scientific papers published by members of the staff of the institution during the year from July, 1925, to June, 1926.

Contributions from the Department of Anatomy. Volume IV. Collected Papers Numbers 58–83.

A collection of reprints of papers written by members of the department staff, many of which would otherwise be difficult of access.

University of Colorado, Boulder

Colorado Plant Life. Francis Ramaley. Volume II. pp. viii + 299. $2.00.

A presentation in simple form of some of the larger facts of plant life in Colorado, for the man or woman who is not trained in botany, but who wishes to gain an appreciation of nature. The book is well illustrated.

Geology and Natural Resources of Colorado. Russell D. George. pp. xv + 228. $2.00.

Some of the subjects discussed are: Rocks and Minerals, Typography and Drainage; Metals and Mining; Structural and Industrial Materials; Water Resources, Soils; Mineral Waters, National Parks, Fish and Game; Climate and Scenery; Geologic Eras.

Zoology of Colorado. Theodore D. A. Cockerell. pp. vii + 262. $2.00.

A semi-technical discussion of living and fossil animals and fishes and of birds, insects and reptiles native to Colorado.

structure aids the geologist to determine where to drill for oil, for instance. Various kinds of rocks have different degrees of magnetization and consequently vary the magnitude and direction of the earth's magnetic field. Refined forms of the compass and similar instruments allow the geologist to measure any magnetic irregularities and speculate upon the cause.

Artificial earthquakes can be caused by small explosions and recorded on seismographs in order to determine the difference in elasticity of the underlying rocks. This information gives clues to mineral deposits and formations in some instances. Electric currents passed through the earth sometimes give valuable information since different kinds of rocks have different conductivities. Other methods not yet in wide practical application include: Radioactivity measurements, transmission of radio waves, temperature records, measurement of natural earth currents, etc.

President Max Mason, of the University of Chicago, was among those who spoke on geophysical exploration for ores, and other reports revealed that the new methods are being used for oil prospecting in the mid-continent fields, in the lead and zinc district of Missouri, Arkansas and Oklahoma, in England, in the Lake Superior copper country and elsewhere.

SCIENTIFIC METHODS IN THE STEEL INDUSTRY

The city of Youngstown, Ohio, to-day lies in the midst of one of the greatest industrial battles in years—the battle iron and steel manufacturers are waging to retain a reasonable margin of profit. In this struggle, scientists are bringing forth many new ideas as weapons against loss. Some of their ideas, if successfully applied, may revolutionize the whole industry. Others seek to cut off a cent from the cost here and another cent there and little by little to keep the production cost down.

Much money is spent by the industry for improvement. Unfortunately, in some instances cost of production is advanced so rapidly by adverse economic conditions that the profit gained through improvements can hardly keep abreast.

It was said that one of the most substantial improvements made recently lies in the use of electricity as a source of motive power. The Youngstown Sheet and Tube Company is installing high pressure boilers to run electric generators at a plant in Ohio. The boilers will be fired by the waste gas from coke ovens. Electric motors used for driving rolling mills, conveyors and other machinery are more economical because they permit the operation of one unit at a time. They increase the flexibility of the mill operation and thereby save time and labor, it is said.

Plants located near sources of water-power are calling upon it to furnish electricity for more economical operation.

In the struggle against advancing costs, iron and steel manufacturers are adopting a more diversified output. They are taking advantage of the fact that if the market for rods and strips slumps they can keep their mills going by turning out tinplate.

Chemists and metallurgists are eyeing the blast furnace critically. "This business of shipping iron ore down here from way out in Minnesota seems to be a waste of money," say some, "Why can't we ship iron down here instead of ore with all its impurities?"

With the use of the blast furnace, iron and steel plants must have a means of manufacturing coke. This entails the operation of a gas plant in most cases. The University of Minnesota has been experimenting with the combination of gas plant and blast furnace. They mix the ore with coal and put the mixture into a coke oven similar to those used in the manufacture of coal gas. They heat the mixture. The iron comes out in a crumbly form and is pressed into cylindrical blocks for shipment to steel plants. It is declared that iron produced in this manner near where it is mined costs a few cents less after shipment to Pittsburgh than iron manufactured in blast furnaces at Pittsburgh.

A process similar to this for the elimination of the blast furnace is being tried by the United States Steel Corporation in its plant at Lorain, Ohio. Metallurgists are reluctant to predict how successful this experiment will be.

More economical methods in the use of fuel are being sought. It has been found that the admonition "cleanliness is next to godliness" holds true in the manufacture of iron and steel as well as in human life. More care is being taken with the cleaning of coke before it goes into the blast furnace. Cleaning of coke eliminates ash. As little as one per cent. of ash taken from the coke takes twenty cents off the cost of production of pig iron.

Attention is being given to purifying the gas from the blast furnace of all particles of dust. Some plants have installed electric precipitators across the path of the gas. The dust particles become charged electrically and can no longer be carried along by it.

Manufacturers are seeking greater fuel economy in the open-hearth furnace where the greatest steel tonnage is manufactured. Before gas and air in this furnace reach the charge that is to be melted down, they pass through heated chambers stacked with fire-brick. These chambers comprise the regenerator. In an effort to make the operation of the regenerators more efficient, the bricks are being stacked in new arrangements to get as much heating surface as possible in a small space. Bricks made of carborundum, which will withstand a higher temperature, also are being tried.

Engineers who have many problems to solve in the rolling mill have not been idle. The United Engineering and Foundry Company, at Pittsburgh, has perfected mills for the continuous rolling of sheet metal. Heretofore, rolling has been a comparatively slow process. The metal has had to be sent through the mill to be rolled for one thickness, backed up and rolled again if a greater degree of thinness is desired. One of the new continuous rolling mills will take a 63,000-pound ingot 8¾ inches thick and roll it down to a sheet of No. 20 gauge metal 41 inches wide at the rate of a ton a minute.

MULTIPLE WALLS FOR THE ABSORPTION OF SOUND

MULTIPLE-LAYERED walls are the most efficient absorbers for deep musical sounds, Dr. E. C. Wente and E. H. Bedell have discovered as a result of experiments at the Bell Telephone Laboratories.

Radio studios, auditoriums and other places, where echoes are troublesome and must be carefully controlled, can be made to have better acoustic properties through the use of a thin, perforated partition, set a short distance out from the main wall.

Formerly such sound studies had to be made in a large room, with good-sized pieces of the material to be tested. Dr. Wente and his associate have invented a way of testing in a small tube, and they claim that it gives results as satisfactory as with the older method. At one end is a telephone receiver to furnish the sound of any desired pitch. Sliding in the other end is a piston, with which the material undergoing test is covered. The echoes formed are studied with a still smaller tube that goes into the main tube at the end near the telephone receiver. On the outside, at the end of this small tube, is a telephone transmitter with which the sounds can be picked up and analyzed.

Sounds of high pitch are largely absorbed by layers of felt, porous "acoustic tile" or wood fiber mixed with felt. Deep or low frequency sounds pass through rather easily. But if the wall is covered with felt, and then, an inch away, a piece of perforated building board is placed, the low frequency sounds are much more completely absorbed. Still better is the effect of two layers of building board, with two air spaces.

Somewhat similar to this is the method recently adopted by engineers of the National Broadcasting Company in designing the new studios of station WRC in Washington. In order to make a sound-proof window between the studio and the control room, three layers of glass of different thicknesses are used. Each piece has its natural frequency, and sounds of a similar pitch would be transmitted. But sounds that get through the first layer are stopped by the second, while any that might still leak through are stopped by the third.

THE TRANSPLANTATION OF SMELT

THE transplanting of fresh-water smelt from eastern Maine to the waters of Idaho is planned in an experiment now being tried out by the United States Bureau of Fisheries, the Forest Service and the Idaho State Game Commission.

Smelt is the natural food of the land-locked salmon, and the object of introducing the Maine smelt in Idaho is to produce an abundant and suitable forage fish to serve as food for salmon and trout. The smelt live principally on minute forms of life which ordinarily occur in abundance in deep-water lakes and turn this into a readily available trout food. Salmon has been introduced in the Redfish Lake section of Idaho, and it is believed that the planting of the smelt will make favorable results much more certain.

The smelt, ordinarily growing to about six inches in length, is remarkably prolific and runs in large schools in the deep waters of the lake. In the early spring these little fish ascend inlets to spawn, the spawn being very minute and adhering to rocks and sticks. The eggs develop readily and hatch in from two weeks to a month, the tiny young migrating immediately to deep water.

The main difficulty encountered in transplanting this fish from the East to the Far West is due to the rapid development of the eggs. The eggs to be shipped to Idaho will be surrounded by a layer of ice and packed in an insulated box, for sending by express. If this method of transportation is not successful, it is planned to attempt a small shipment by air mail.

ITEMS

A NEW type of loud-speaker, that can give out sounds 300 times as loud as any of the older types, has been invented by engineers at the Bell Laboratories. However, there is no danger that this will form a new source of annoyance to apartment-house dwellers, for the horn is so large that it is not adapted for use with ordinary radio sets. It is intended particularly for out of door public address systems, and for talking motion pictures in large theaters. The new device is the invention of Dr. E. C. Wente and A. L. Thuras. It employs a moving coil, in which the entire electromagnet that all such sound reproducers contain, moves back and forth according to the current flowing through it. In small speakers, the magnet is fixed, and moves a small armature attached to the vibrating diaphragm from which the sound waves start. This is not new, but Dr. Wente and his associate have worked out improvements in the design, and in the way the diaphragm is connected to the horn. As a result, 30 watts of electrical power can be used in the horn, instead of about 5 watts, the previous maximum. Its efficiency, in converting this electrical power to sound, is about 50 times greater than older speakers, so that good reproduction can be obtained about 300 times as loud as formerly.

THE only case of rickets that experts from the U. S. Children's Bureau found in a recent survey of 600 Porto Rico babies was in an infant that had spent five of its six months in a cellar lighted only by electricity. The survey was undertaken under the direction of Miss Grace Abbott, chief of the bureau, to determine the effect of the tropical sun on rickets, the disorder of the mineral chemistry in the bodies of young children that is prevented by the action of ultra-violet rays. It is especially desirable, Miss Abbot pointed out, to have a series of X-ray pictures of the bones of babies who live in the tropics, because they normally spend most of their waking hours with their little bodies completely exposed to the beneficial action of the sun. The photographs will be used to compare with those of children in temperate climates so that some sort of a standard can be obtained of what the healthy bones of a growing child should look like.